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MONTEREY, CALIFORNIA

THESIS

**UNATTENDED GROUND SENSORS FOR
EXPEDITIONARY FORCE 21 INTELLIGENCE
COLLECTIONS**

by

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June 2015

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**UNATTENDED GROUND SENSORS FOR EXPEDITIONARY FORCE 21
INTELLIGENCE COLLECTIONS**

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Submitted in partial fulfillment of the
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ABSTRACT

As our adversaries continue to evolve in complexity, the U.S. Marines adapt in kind with its design and intent through its Expeditionary Force 21 (EF 21) Capstone. EF 21 stresses the need for increased persistent intelligence collections capabilities and the optimization of existing assets. Current requirements for Unattended Ground Sensors (UGS) limit usage in non-permissive environments beyond the Area of Operations, contrary to the new demands of EF 21.

UGS shortfalls include the technologies in use and the capability of the Marines employing them. The fusion of reconnaissance Marines with commercial state-of-the-art UGS expands the current ground intelligence collections capability to be rapid and adaptable for EF 21. This concept required researching the reconnaissance and intelligence battalions, the UGS associated individual standards, and existing UGS from McQ Incorporated and the Defense Advance Research Products Agency. Analysis of this research consisted of a Systems Engineering approach applied the Doctrine, Organizations, Training, Materials, Leadership, Personnel, and Facilities fields for UGS.

The result was a new table of organization for the Marines ground sensor platoons, focusing on restructuring these units for operational flexibility, fusion with reconnaissance Marines to extend tactical reach, and technological upgrades to advance all existing UGS capabilities.

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LIST OF ACRONYMS AND ABBREVIATIONS

1stLt	First Lieutenant
AD	Air Delivery
ADAPT	Adaptive Sensor System
ADCON	Administrative Control
AMOS	Additional Military Occupational Specialty
BFSB	Battlefield Surveillance Brigade
BSC	Battlefield Surveillance Company
C3	Command, Control, and Computers
Capt	Captain
COIN	Counter Insurgency
COP	Common Operational Picture
COTS	Commercial Off The Shelf
Cpl	Corporal
DARPA	Defense Advanced Research Product Agency
DOD	Department of Defense
DOTMLPF	Doctrine, Organizations, Training, Materials, Leadership, Personnel, Facilities
EF 21	Expeditionary Force 21
EO	Electrical Optical
EOTG	Expeditionary Operations Training Group
ETU-II	Encoder Transmitter Unit II
EW	Electronic Warfare
FMV	Full Motion Video
GCC	Geographic Combatant Commander
GCE	Ground Combat Element
GSP	Ground Sensor Platoon
GPS	Global Positioning Satellite
GySgt	Gunnery Sergeant
HRST	Helicopter Rope Suspension Techniques
HQMC	Headquarters Marine Corps
HQ Tm	Headquarters Team (Ground Sensor Platoon)
IED	Improvised Explosive Device
IMINT	Imagery Intelligence
IR	Infrared

IRID-II	Infrared Intrusion Detector II
ISR	Intelligence Surveillance and Reconnaissance
LCpl	Lance Corporal
LP/OP	Listening Post / Observation Post
MAGID	Magnetic Intrusion Detector
MAGTF	Marine Air Ground Task Force
MARFORRES	Marine Forces Reserve
MARSOC	Marine Special Operations Command
MCRP	Marine Corps Reference Publication
MCWP	Marine Corps Warfighting Publication
MSAT	Mobile Situational Awareness Tool
MASINT	Measurement and Signatures Intelligence
MCISR-E	Marine Corps ISR Enterprise
MEU	Marine Expeditionary Unit
MOS	Military Occupational Specialty
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OPCON	Operational Control
PIR	Passive Infrared
PP&O	Plans, Policies, and Operations
RECON	Reconnaissance
RF	Radio Frequencies
RR	Radio Relay
SA	Seismic Acoustic
SALUTE	Size Activity Location Unit Time Equipment
SATCOM	Satellite Communications
SARC	Surveillance and Reconnaissance Center
SARCC	Surveillance and Reconnaissance Coordination Cell
SE	Systems Engineering
SES	Sensor Employment Squad
SET	Sensor Employment Team
Sgt	Sergeant
SMG	Sensor Monitoring Group
SOF	Special Operations Forces
SOP	Standard Operational Procedure
SPIE	Special Insert and Extract
SPMAGTF	Special Purpose Marine Air Ground Task Force
SSgt	Staff Sergeant
SSOC	Surveillance Sensor Operators Course

T&R	Training and Readiness
TM	Technical Manual
TNet	Terrestrial Network
TRSS	Tactical Remote Sensor System
UGS	Unattended Ground Sensors
UHF	Ultra High Frequency
USMC	United States Marine Corps
VHF	Very High Frequency
WSN	Wireless Sensor Network

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I. INTRODUCTION

A. SITUATION

The current ground reconnaissance capability of the United States Marine Corps (USMC) far exceeds past generations due to the technological advancements, organizational structure of the units, and regimented training [1]. With a diverse set of radios for tactical voice and data communications, day and night long range optics, precision weapons systems, and state-of-the-art commercial off the shelf (COTS) photography equipment, today's Marine Reconnaissance community incorporates the technology to effectively command and control, maneuver, and collect intelligence in support of any type of operation [1]. Ground reconnaissance Marines continue to organize, train, and deploy for some of the most difficult missions tasked to the Department of Defense (DOD), making them prepared, versatile, and eager to test their mettle against America's greatest foes [1]. However, the recent use of ground reconnaissance forces in support of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) resulted in more overt and direct offensive operations as opposed to clandestine intelligence collections missions [2]. This change in mission was a result of several factors, the most significant of which was the sheer difficulty of counter insurgency (COIN) operations centering on the locals, who represented a high risk of compromise, desert terrain providing sparse concealment, and occupied areas laced with Improvised Explosive Devices (IEDs) [2].

Due to technological advancements, several commanders, such as the I Marine Expeditionary Force (MEF) Commanding General, desire Persistent Intelligence Surveillance and Reconnaissance (PISR) assets to support long range, all weather, reduced footprint, and multi-sensor collections in any environment [3]. Ground reconnaissance forces may be limited in their ability to support PISR missions, whereas Unattended Ground Sensors (UGS) possess several permissive features. Several USMC entities and emerging intelligence concepts (*Expeditionary Force 21* and the *Marine Corps ISR Enterprise Roadmap*) share common requests for UGS to have the capability and capacity to advance the collection of information, if employed correctly, utilized

properly, and equipped with state of the art technologies. Figure 1 displays an example of the current USMC capability for the employment of UGS by a Ground Sensor Platoon (GSP), able to support ground reconnaissance missions with Measurement and Signatures Intelligence (MASINT) and Imagery Intelligence (IMINT) collections [4].

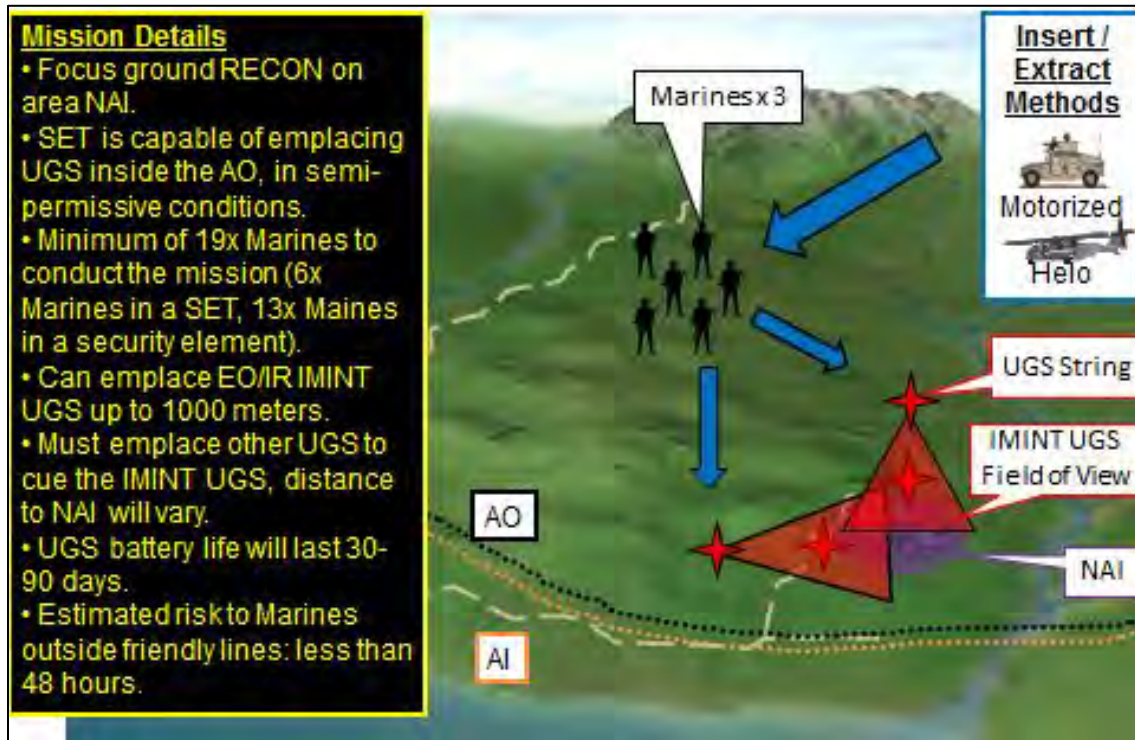


Figure 1. Doctrinal GSP Mission Vignette, after [4]

For this example, the Sensor Employment Team (SET) receives tasking to employ UGS to collect intelligence on a Named Area of Interest (NAI), which is an area friendly forces will monitor because it holds value to the advisory's course of action, or it has a relationship with one or more of the intelligence requirements [5]. The GSPs have limits in insert methods, stealth, security, size, maneuver inside the Area of Operations (AO), and requirement to place UGS close to the NAI for cueing of additional IMINT UGS [5]. The AO is an area assigned to a commander utilized to accomplish his mission and protect his forces [5]. One of the key strengths of this type of mission is the relatively shorter duration of Marines outside friendly lines, in comparison to that of a ground reconnaissance or infantry unit that could require more time in high-risk areas to

complete their mission. Additional strength includes the type of equipment they can use, the long battery life of the UGS, and the range of the collections capability with UGS.

Figure 2 displays a traditional ground reconnaissance (RECON) mission conducted by Marine reconnaissance elements.

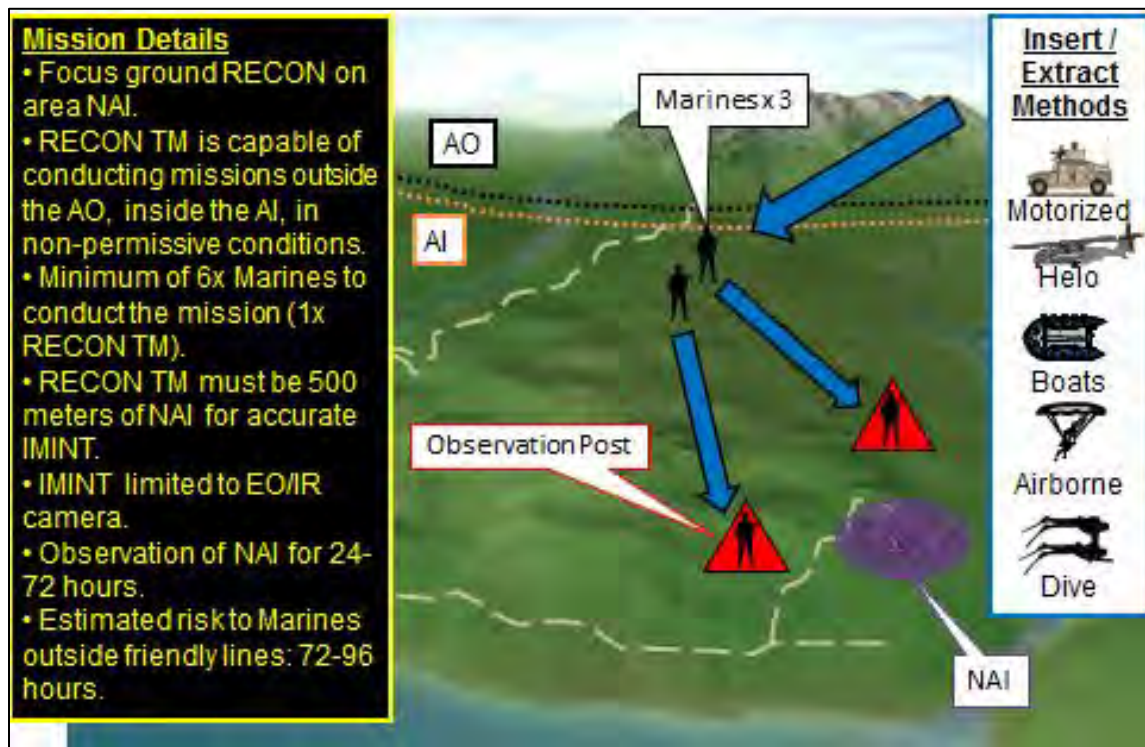


Figure 2. Doctrinal Reconnaissance Team Mission Vignette, after [1]

The ground reconnaissance units are limited by their technical capability, length of time for collections, and exposure to Marines outside friendly lines in comparison to the GSP mission [1]. However, the ground reconnaissance elements can utilize several more methods to access the battlespace, can operate in much smaller sized units, and can perform their missions beyond the AO and inside the Area of Interest (AI) [1]. The AI is the geographical area that contains enemy forces that can jeopardize the mission, which usually falls beyond the AO [5]. The AI is usually the area more focused on for intelligence collections, is usually non-permissive while portions of the AO might be semi-permissive or permissive [5]. Intelligence collections missions in the AI require

greater support and higher risk estimates due to their extended distances from friendly bases and threat estimates. Reconnaissance Marines also receive greater training in complex threat situations, which makes them more capable in operating in the AI with limited support [1].

Analysis of the capabilities of the GSP and Marine reconnaissance units defines certain strengths for combining to achieve maximum potential for intelligence collections. Figure 3 displays a combination of the assets with commercial off the shelf equipment to augment the existing UGSs' capability.

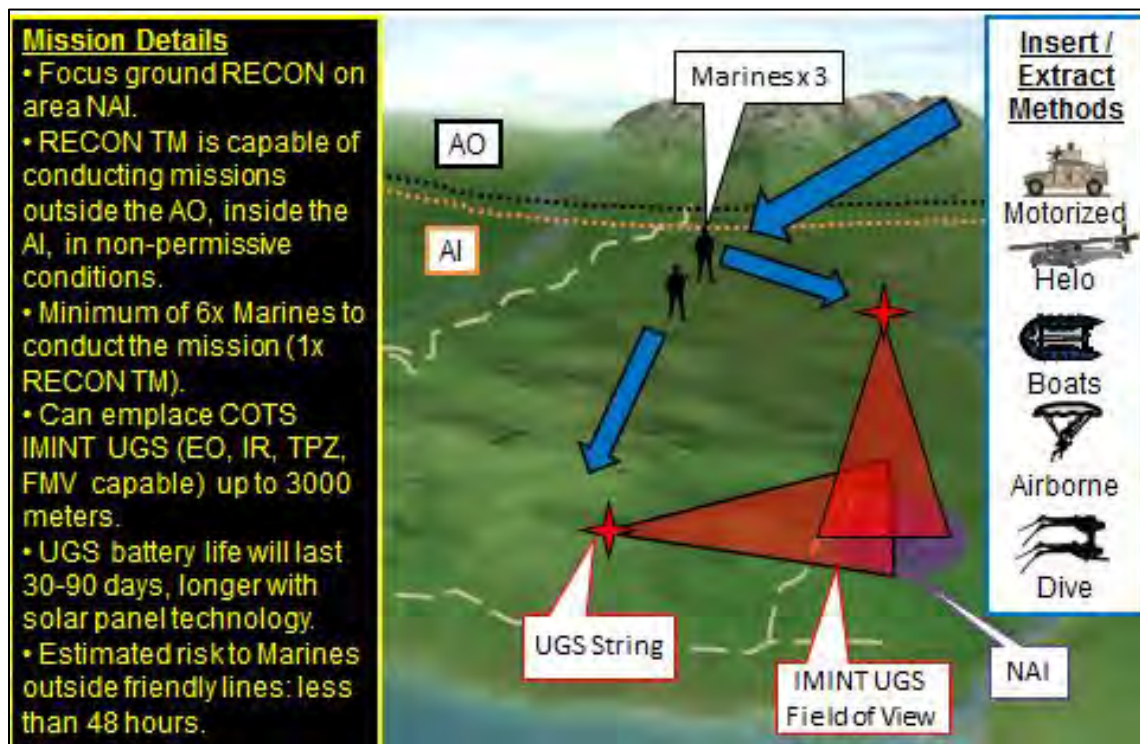


Figure 3. Hybrid UGS/Reconnaissance Team Vignette, after [1], [4]–[6]

To support *EF 21* with ground reconnaissance collections, UGS will need advanced communications features, extended IMINT collections ranges, and increased durability and flexibility to adapt to high threat areas. Figure 3 shows the use of ground reconnaissance Marines to employ COTS UGS, with great tactical expertise, increased variety of Special Insert and Extract (SPIE) methods, and small-sized elements to aid in

concealment for operations beyond the AO and in the AI. The COTS UGS contain video imaging capabilities for Full Motion Video (FMV) and Tilt Pan Zoom (TPZ) for a range of 3000 meters, which is three times that of the current range for USMC UGS [6]. Table 1 is a comparison of the three missions displayed in Figure 1, 2, and 3.

Table 1. Ground Reconnaissance Mission Comparisons, after [1], [4]–[6]

	Ground Reconnaissance Mission Comparisons		
	Mission: Conduct ground RECON on a point Named Area of Interest (NAI).		
	Ground Sensor Platoon	Reconnaissance Battalion	Hybrid (RECON Team with Unattended Ground Sensors (UGS))
1. Maneuver Space	Limited to inside the Area of Operations (AO) in a semi-permissive environment.	Capable of operating inside the AO and the Area of Interest (AI) in a non-permissive environment.	Capable of operating inside the AO and the AI in a non-permissive environment.
2. Size	19x Marines: 6x Marines in a Sensor Employment Team (SET), 13x Marines in a security element.	6x Marines: one RECON Team.	6x Marines: one RECON Team.
3. Insert / Extract Methods	Dismounted, Motorized, Rotary Wing Air Craft (RW A/C).	Dismounted, Motorized, RW A/C, Helicopter Rope Suspension Techniques (HRST), Small Boats, Airborne, Combat Dive.	Dismounted, Motorized, RW A/C, HRST, Small Boats, Airborne, Combat Dive.
4. Duration for Maneuver	Less than 48 hours	72-96 hours	Less than 48 hours
5. Duration of Collections	30-90 day battery life.	48-72 hours of observation.	30-90 day battery life, longer with solar panel technology.
6. Imagery Intelligence (IMINT) Type	UGS capable of daytime Electro Optical (EO), nighttime Infrared (IR) stills.	Tactical camera capable of EO and IR stills.	Other COTS UGS capable of daytime EO and nighttime IR stills, Full Motion Video and Tilt Pan Zoom.
7. IMINT Range	1000 meters	300-500 meters	3000 meters
8. Other Collections Capabilities	Measurement and Signature Intelligence (MASINT): Seismic, Acoustic, Magnetic, and IR UGS.	Human Intelligence (HUMINT).	HUMINT and MASINT: Seismic, Acoustic, Magnetic, radar, and IR UGS.

The hybrid mission outlined in Figure 3 surpasses the others in nearly all the examined categories, allowing for significant capabilities in IMINT and MASINT collections, and for the ground reconnaissance elements the collections of Human Intelligence (HUMINT), which is intelligence derived from collection or reporting from human sources [5]. The reason this is significant is that *EF 21* requires this type of capability to support similar missions. *EF 21* demands an increased level of flexibility for Special Purpose Marine Air Ground Tasks Forces (SPMAGTFs) to deploy, adapt, and operate in a specified geographical region at any time [7]. To support this, the USMC

needs a revamped on-the-ground UGS and reconnaissance capability to monitor enemy activity and collect vital intelligence.

B. PURPOSE

The purpose of this research is to analyze current/existing models for managing, employing, and sourcing UGS for the USMC while focusing on the technological advancements of the units, as well as the training, and current related mission sets offered by such technology insertions. This research examines the USMC's best approaches toward asset integration for multi-source intelligence collections, specifically UGS as cueing assets, all to better support *EF 21* intelligence collections missions. Potential benefits include doctrine updates and table of organization and table of equipment modifications. Units that can benefit from this research include Marine Corps System Command (MARCORSYSCOM), Intelligence Department for Headquarters USMC, and the Navy and Marine Corps Intelligence Training Center.

When analyzed as a part of the current intelligence collections concepts, UGS are under-utilized and misallocated in medium to high threat areas of interest. UGS contain immense potential, yet due to their low quantities and limited exposure, they have provided little impact on modern intelligence collections. This thesis analyzes and compares the units and individual Marine skillsets that employ UGS, and the different existing UGS technologies to determine better management for and employment of UGS to support intelligence collections missions in non-permissive environments beyond the AO.

C. METHOD

This thesis focuses on the evaluation of current organizational units relative to UGS employment, technologies associated with UGS, and a Systems Engineering (SE) approach to improve the use of such systems in the USMC for *EF 21* intelligence collections. This analysis consists of the employment methods, management strategies, monitoring unit's capabilities and systems, and conceptual integrations. A detailed analysis of the responsibilities and capabilities of the USMC's intelligence battalions and reconnaissance battalions creates opportunities for new missions focused on the employment of multiple advanced UGS to aid in the answering of Commanders Critical

Information Requirements (CCIRs). Highly capable UGS can reduce the friendly force footprint while still maintaining or enhancing valuable intelligence collections as the USMC continues to support a wide range of mission sets.

This thesis organizational structure is as follows:

Chapter II: Literature Analysis. This chapter explores the history, doctrine, and other key documents from the UGS and intelligence community for reference regarding the current capabilities of UGS and the demand for their use. Two main documents provide the literature foundation of this research, the *Expeditionary Force 21 (EF 21) Capstone Concept* of March 2014 and the *Marine Corps ISR-Enterprise (MCISR-E) Roadmap* of April 2010. These two documents define a new concept for intelligence collection, asset management, and sensor integration based on the Service's recent combat history fighting insurgents. The compilation of this literature presents compelling results for the demand of sensors at all levels and the integration of multiple sensors to enhance information flow and the intelligence cycle. However, current gaps exist in the employment methods, management, and sourcing of UGS, as well as the exploration of emerging and adaptive technologies. The use and ownership of UGS in the USMC cannot currently maintain pace with the concepts presented in *EF 21* and *MCISR-E Roadmap*. Using these two documents as a new foundation for intelligence collections operations, extensive research was conducted to identify and highlight needed changes to the units owning UGS, the types and quantities of UGS available. In addition, research also focused on the proper procedures and training for the monitoring and employment of these assets, as well as an overall evaluation of the UGS as an intelligence collection system in the USMC.

The Naval Postgraduate Master's Thesis *Mobile Situational Awareness Tool: Unattended Ground Sensor Based Remote Surveillance System* from September 2014 by Captains Bradley C. Palm and Ryan P. Richter, USMC, served as a guide with respect to UGS related to new emerging force protection capabilities for early warning detections. Although designed for a separate warfighting function in force protection, their research presents several results for an UGS system with potential to further PISR integration at the tactical level in multiple environments.

Chapter III: Research Analysis. The research for this thesis required focusing on the units that owned and employed UGS, and the current technologies associated with UGS for the USMC, DOD, and the commercial sector. The units section discusses the structure, capabilities, and limitations of the intelligence battalions and reconnaissance battalions in the employment of UGS. Once the appropriate data set was collected, evaluation of employing and managing units was conducted with a review of the Training and Readiness Manuals for the intelligence and reconnaissance Military Occupational Specialties (MOSs) for the management of UGS. The technological section displays the current and other existing UGS for comparison of the qualitative and quantitative analysis of the current state of the art technologies.

Chapter IV: Systems Engineering Analysis. This chapter uses the information from Chapters II and III and the context of a SE analysis and design to discuss the best way to improve UGS in the USMC to support *EF 21* intelligence collections missions.

This thesis does not incorporate any analysis of U.S. Army UGS; although the Army and Marine services have many similarities, their current use of UGS differs significantly. The U.S. Army presently uses UGS primarily as a force protection asset and is revamping their doctrine and technologies to support intelligence collections, and is still debating who would own which UGS. All this makes for difficult analysis in comparison of the U.S. Army and USMC capabilities. In addition, although UGS integrate well with Unmanned Aerial Systems (UAS) for PISR missions, this thesis does not discuss the relationship between the two in detail. UGS may require deployment into areas where the air space is denied, rendering UAS useless. On account of this discrepancy and several other issues, the analysis or discussion of integration between UGS and UAS is not in this thesis.

D. END STATE

This thesis recommends a restructuring of the USMC surveillance units to employ emerging UGS capabilities more effectively. Potential benefits of this research include USMC structural and technological modifications that alter the service's intelligence collections operations towards an increased quality and quantity of UGS for future

operations. This research produced results for recommendations in new systems for purchase, table of equipment and table of organizational modifications, and possibly doctrinal updates for the USMC.

The result of this research presents a more effective system for the employment, management, and technologies associated with UGS in the USMC to support *EF 21* intelligence collections missions. Chapter IV displays a detailed plan for upgrades to the doctrine, organizations, training, materials, leadership, personnel, and facilities associated with UGS in the USMC. This thesis presents valid solutions to an existing problem that requires rapid attention and can result in immediate effects on the battlefield.

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II. LITERATURE REVIEW

A. OVERVIEW

The purpose of this chapter is to review essential documents to formulate a background, explore relative concepts and visions, and lay a foundation for continued research in the relationship between UGS and ground reconnaissance. Exploration of key related documents will give definition to the unique and challenging roles for the management, employment, and ownership of UGS in the USMC. The organization of this chapter consists of three parts, the introduction, literature analysis, and conclusion. The introduction section contains this overview, followed by the historical background portion, then the supporting doctrine portion focused on the USMC's intelligence collections, ground reconnaissance, and remote UGS publications. The historical and doctrine portions focus on UGS development, employment, mission planning, the ground reconnaissance/UGS relationship and concepts relative to this thesis.

The literature analysis consists of four portions, each selected for its current relevancy to the USMC and UGS. The first portion reviews the *Expeditionary Force 21 Capstone* to show the current and future USMC vision. The second portion reviews the *Marine Corps Intelligence Surveillance Reconnaissance Enterprise Roadmap* to show the current and future USMC intelligence development plan. The third portion reviews the *Mobile Situational Awareness Tool: UGS Based Remote Surveillance System* thesis project to show the use of modern-day cell phone technology in UGS for infantry solutions. The last section summarizes the key points of this chapter. The end state of this chapter is a review of key events and documents that directly affect current and future UGS related roles, missions, and technologies for the USMC.

B. HISTORY

The implementation of UGS in the USMC originated during 1967 in the Vietnam War to advance the methods of surveillance and target acquisitions [4]. The development of UGS for this Low Intensity Conflict was driven by the lack of success with the U.S. Air Force's Rolling Thunder campaigns (strategic bombing along the Ho Chi Min trail),

for the enemy still moved freely along the trail and executed successful ambushes around it [8]. The use of technology to advance ground intelligence collections revolutionized the flow of information on the battlefield while reducing the risk to soldiers. Although the use of UGS along the Ho Chi Min trail had limited success as part of a sporadic integrated barrier plan throughout over 40 miles of triple canopy jungle, more significant after action points were noted in the battle of Khe Sanh [8]. Due to a detailed and accurate Intelligence Preparation of the Battlespace plan called Niagara I, seismic and acoustic UGS were air delivered and emplaced by ground reconnaissance elements around the USMC's 26th Marine Regiment's defensive perimeter, focused on possible enemy ingress and egress routes. As the enemy began to attack, these UGS provided limited use for intelligence collections on enemy mortar and artillery positions; however, their value regarding enemy movement became an essential element contributing to the U.S. Marines victory [8]. These UGS provided the Marines an ability to gain indications and warnings of enemy advancements, to gain and maintain situational awareness on enemy movement of troops and equipment, target enemy forces, reduce friendly casualties, and collect valuable intelligence as to the enemy's whereabouts and their future operations [8]. During Operations Desert Storm in 1991, UGS saw little use due to the fast-paced operations of a large-scale mechanized offensive, the engagement in the desert environment of Kuwait and Iraq (flat open terrain, limited enemy hiding locations), and the advanced use of satellites and aerial reconnaissance planes for IMINT collections. The U.S. military did resort back to Vietnam-era UGS employment techniques for OIF from 2002–2008 and OEF from 2001–2014 in Afghanistan to support COIN operations [9]. OIF saw the use of seismic, acoustic, magnetic, passive infrared, and short-range imaging UGS to support intelligence collections for infantry battalions focused on tracking enemy patterns of movement, counter indirect fire missions, and counter IED missions in desert and urban terrain. Similar UGS were used in OEF, with the addition of IMINT UGS with ranges of 200–300 meters (nearly triple that of the existing capability), to support infantry battalion operations as well as larger scale division operations for rear area security and pattern analysis missions. Throughout the span of these major conflicts, proper utilization and employment of UGS has provided

crucial intelligence to the warfighter. History has shown that with technological advancements, and in the hands of the right units, UGS can be employed to provide significant tactical surveillance and target acquisitions to aid in combat operations.

C. DOCTRINE

1. USMC Intelligence Collections Publication

Solid understanding of ground reconnaissance operations, including the employment of UGS, requires extensive knowledge of military intelligence doctrine, a cornerstone of this being intelligence collections doctrine. *The Marine Corps Warfighting Publication (MCWP) 2-2: MAGTF Intelligence Collection* of 2004 covers the fundamentals, collections requirements management, intelligence collection operations management, and planning and execution of USMC intelligence collections operations [10]. A thorough analysis of this document leads to several important concepts relative to ground reconnaissance and UGS operations. The first and major significant definition comes in Chapter 1: Fundamentals, with the definition of the USMC's Intelligence Cycle, displayed in Figure 4, the driving force behind all USMC intelligence operations.

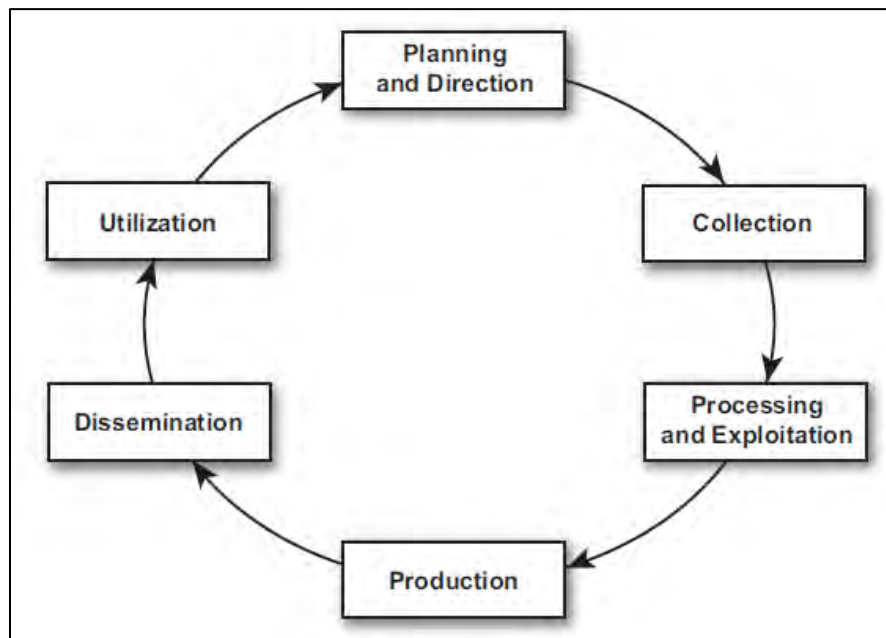


Figure 4. The Marine Corps Intelligence Cycle, from [10]

Chapter 1 goes on to state that the Intelligence Battalion Commander is responsible for the coordination, development, and dissemination of intelligence collection plan, which includes all UGS missions as well as the functioning of the Surveillance and Reconnaissance Center (SARC) [10]. The SARC is utilized at the MAGTF level to monitor, command and control, and review / disseminate reporting from all ground reconnaissance operations. Additionally, this chapter highlights that both the GSP and ground reconnaissance forces are MAGTF level assets, which means they may be task organized to smaller elements for mission support but ultimately the MAGTF Commander owns them [10]. Chapter 2: Collections Requirements Management describes the planning and coordination of ground reconnaissance missions, the Division G-2 is tasked as the responsible officer [10]. Also discussed in this chapter are two key intelligence collections concepts relative to proper and successful collections operations, regardless of the type. The first are the collections strategies of cuing (one asset signals another), redundancy (two or more of the same type of assets collecting on one site), mixing (two or more different types of assets collecting on the same site), and integration (one asset passed to a secondary site for further collections) [10]. The second key fundamental point established are the basics for intelligence collection planning that consists of Intelligence Requirements, Indicators, Specific Information Requirements (SIRs), collections assets and resources to be employed, reporting criteria and instructions, and remarks [10]. On the surface, these may all sound similar and bland; however, each subject serves a powerful role in the definition of a successful collections plan. Chapter 3: Intelligence Collection Operations Management shows that there are several factors such as the environment, asset capabilities, range, and pattern of life factors all weight in when collection managers conduct asset tasking [10]. Ground reconnaissance units' roles and missions are then defined, stressing the importance of establishing the SARC and associated reporting, most of which are focused are dated conventional warfare types (Size Activity Location Unit Time Equipment [SALUTE] Report hydrographic survey, beach survey, landing zone, and river report) [10]. MASINT is defined as the intelligence derived from qualitative and quantitative data sets collected by technical instruments from sources other than signals (sensors, radars, radiation,

temperature, etc.), noting that GSP with UGS is the only organic MASINT asset for the USMC [10]. Once the strategies are in place, the fundamentals are established, and the plan is set, the Intelligence Collections Synchronization Matrix is created, such as the example displayed in Figure 5.

TIME	T + 10	T + 24	T + 36	T + 48
Friendly Event	Penetrate 80th Corps	Shape 90th Corps	Shape 90th Corps	Shape reserve
Threat Event		Reserve departs assembly areas	Reserve deploys combat formation	Corps artillery forward deploys
Decision Points	Shift main effort to aviation combat element		Shift shaping actions	
Intelligence Event (PIR)	NAI 24-will the reserve reinforce 90th Corps	NAI 1-identify reserve assembly areas	NAI 3-identify reserve locations	NAI 3-identify Corps artillery refueler locations
Intelligence and Recon Collectors	JSTARS Force Recon UAV/ATARS Ground Sensors	JSTARS Radio Battalion	Force Recon UAV/ATARS	JSTARS Force Recon

Figure 5. Notional Intelligence Synchronization Matrix, from [10]

Chapter 4: Planning and Execution, stresses the importance of ground reconnaissance and sensor implant missions to be well coordinated with fires and maneuver operations, which requires detailed planning and substantial contingencies [10]. This chapter also highlights that both the intelligence battalions and reconnaissance battalions are required to task organize their forces to support MAGTFs smaller than a

MEF, which means they must be able to detach small sized elements (company, platoons, teams) to support other units [10]. Appendix C contains a sample Collection Plan that presents some interesting details relative to ground reconnaissance and UGS operations. The tasks for the force reconnaissance company state that they are responsible to implant UGS, and yet GSP is not, which was a dated concept that creates minor friction and controversy between the units [10]. Contrary to Appendix C, Appendix D, a Sample Collections Update Paragraph for intelligence summary shows GSP being responsible for the emplacement of UGS [10]. Although this publication is in need of updates and presents some conflicting points relative to ground reconnaissance and UGS employment, it serves as a cornerstone for USMC intelligence doctrine and is well utilized in today's real-world operations.

2. USMC Ground Reconnaissance Operations Publication

The *MCWP 2-25: Ground Reconnaissance Operations (DRAFT)*, of 2012, details specifics related to full spectrum operations, units and organization, command and control, mission development, operational types and planning, methods of maneuver, communications, and intelligence operations and reporting dissemination for expeditionary ground reconnaissance missions [1]. Almost immediately, the forward displays the importance of ground reconnaissance units using UGS, which as shown through review of the *MCWP 2-2*, can present issues between them and GSP [1], [10]. A step in the right direction for categorizing ground reconnaissance assets presents in Chapter 2: Units and Organizations, which lists GSP as a ground reconnaissance asset, not just a MASINT asset as shown in the *MCWP 2-2* [1], [10]. However, it does not show that GSP employs the UGS, and that they train others to do so, leaving the force reconnaissance company with the task to implant and recover UGS [1]. Command and control is an important warfighting function and often times a burden, however the updates in roles and terminology, such as Surveillance and Reconnaissance Coordination Center (SARCC) (vice the SARC noted in both the *MCWP 2-2* and *MCRP 2-24B*) gives new life to structure not seen previously [1], [4], [10]. Figure 6 shows the SARCC as part of the Intelligence Operations Center.

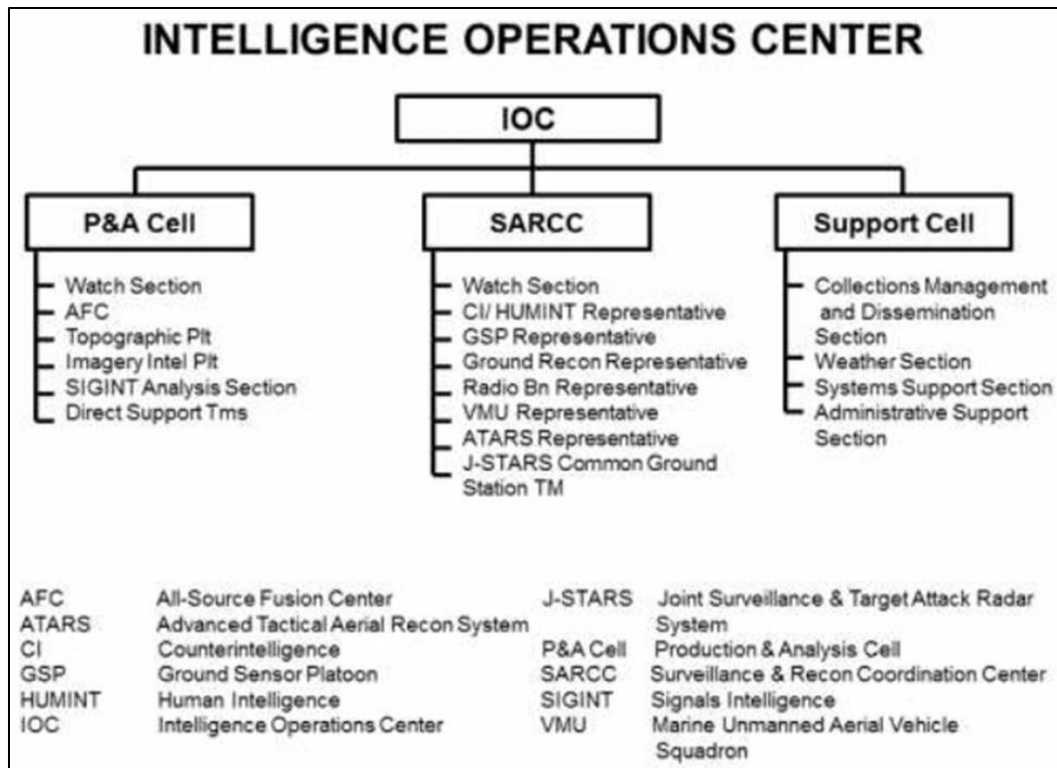


Figure 6. Intelligence Operations Center, from [1]

Chapter 5: Operations, highlights the different ground reconnaissance operations and their associated tasks as displayed in Table 2 [1].

Table 2. Ground Reconnaissance Tasks by Operation, from [1]

<i>Operation</i>	<i>Surveillance</i>	<i>Reconnaissance</i>	<i>Target Acquisition</i>	<i>Target Interdiction</i>
TASKS:	<ul style="list-style-type: none"> • Observe • Locate • Detect • Determine • Identify • Evaluate • Report • Confirm • Deny 	<ul style="list-style-type: none"> • Report • Locate • Detect • Identify • Confirm • Deny • Pinpoint 	<ul style="list-style-type: none"> • Mark • Locate • Detect • Identify • Pinpoint 	<ul style="list-style-type: none"> • Attack-by-fire • Suppress • Disrupt

This is important in Chapter III of this thesis during the evaluation of capabilities for both ground reconnaissance units and GSP. Interesting to the thesis, yet in a slightly different direction, this chapter describes Hunter Killer Operations and in doing so notes the importance of ground reconnaissance forces being equipped with state of the art sensor and counter sensor technology [1]. Chapter 8: Intel Operations and Reporting Dissemination, reviews the topic of sensor data set management, where it states that ground reconnaissance Marines emplace UGS, not GSP Marines [1]. This same chapter details the monumental importance of intelligence cohesiveness, stressing that intelligence as a warfighting function is a team effort and UGS must be implanted to support ground reconnaissance operations [1]. The chapter continues on to state in the MASINT section that GSP is to provide logistical, maintenance, and monitoring equipment for UGS, and that ground reconnaissance units will emplace UGS in the surveillance area [1]. With a clear understanding of the doctrinal relationship between ground reconnaissance units and employment concepts, a thorough analysis can be conducted in Chapter III of this thesis to depict the best possible options for UGS employment and management, as seen in Chapter I, Figure 3.

3. USMC Remote Unattended Ground Sensors Publication

The *Marine Corps Reference Publication (MCRP) 2-24: Remote Sensor Operations*, updated in 2004, covers key UGS related topics such as the fundamentals, the Tactical Remote Sensor System (TRSS), Command and Control of, planning for, the execution of, and training for remote UGS operations. The USMC's doctrine on UGS and UGS-employment is dated, as most of the publication is extracted from the 1997 version; however, it still provides a noteworthy base for the planning and execution of UGS operations [4]. Chapter 3: Command and Control of Remote Sensor Operations, offers relative facts for the establishment of multiple integrated networks to facilitate sensor reporting, while indicating the need for Sensor Monitoring Sites to be supported by infantry units and implant missions to be supported by ground reconnaissance units, as displayed in Figure 7.

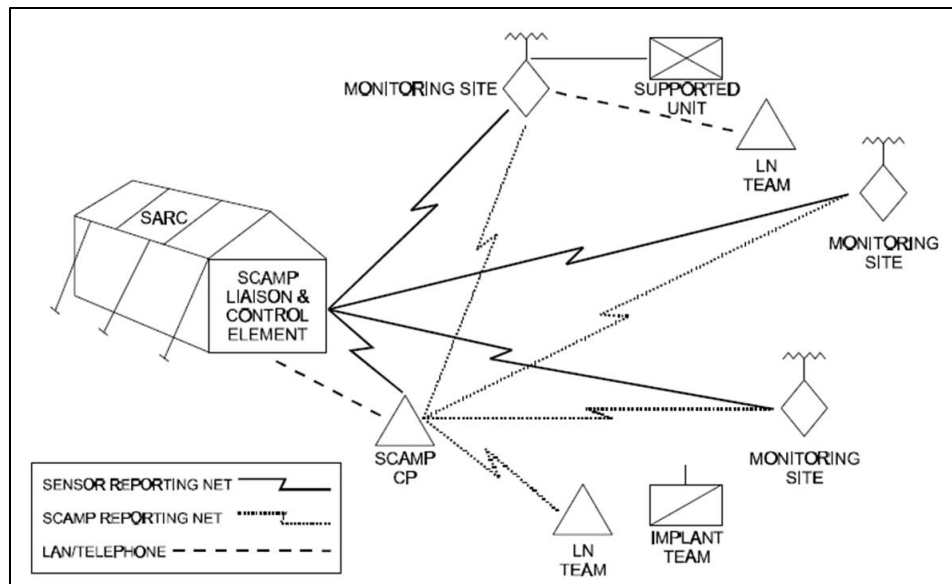


Figure 7. Sensor Control Agencies, from [4]

Chapter 4: Planning for Remote Sensor Operations, emphasizes the importance of planning for UGS operations, the development of a sensor surveillance plan, sensor employment plan, the use of the sensor employment planning cycle, and the socialization of this plan through the proper chain-of-command [4]. Figure 8 depicts the Sensor Employment Planning Cycle, which is tied to all sensor reporting and missions.

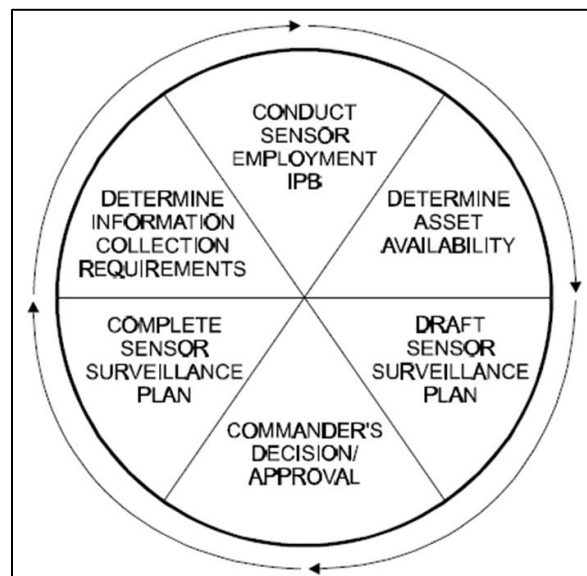


Figure 8. Sensor Employment Planning Cycle, from [4]

Despite Chapter 2 on TRSS covering the old technologies used, this publication contains well-structured post-Vietnam era planning concepts and formats that were well utilized by GSP commanders in OIF and OEF. Chapter 5: Execution of Remote Sensor Operations, describes the importance of proper accomplishment of UGS operations, the importance of their information collected for future operations and the networking of communications to ensure the UGS are able to collaborate and report the data sets [4]. Next, the chapter underscores the value of an approved UGS employment plan to ensure the collected intelligence gains proper dissemination, and the significance of UGS emplacement missions to ensure success of the overall surveillance plan [4]. Chapter 2: TRSS, is the most out-of-date portion of this publication; although it describes the TRSS quite well, the technology discussed is very old and outdated [4]. As the technology has been upgraded, the doctrine has been only slightly modified, which implies that the lack of recent updates for this MCRP shows solid foundational concepts for the planning and employment UGS, regardless of their type. This publication needs updates and modifications on current units, missions, and responsibilities, which would also serve as an opportunity for the TRSS capabilities to be presented while the technical specifics are left in the Technical Manuals. The relationship between doctrine and technology is constantly morphing, for UGS the two need to be separated, leaving the doctrine to focus on UGS role in intelligence operations and the Technical Manuals to focus on the equipment specifics, for as one changes it does not necessarily require updates from the other. One area where this publication is vague is in Chapter 5: Execution of Remote Sensor Operations, for it lays out general parameters and considerations for the employment of UGS, yet when compared to doctrine for snipers or ground reconnaissance Marines, it lacks specifics for field-craft, maneuver, mission graphics, and formations of units [4]. Although this section only covers the basics, it does not negatively influence the sensor community, for it now drives the GSP commander to develop new, specific Standing Operating Procedures (SOPs) for their unique missions and environments. The history and doctrine for UGS shows great methods and concepts for the use of UGS on the battlefield; coupled with modern concepts and technology, these fields can serve as great examples for future missions to increase the amount and roles of UGS employed while reducing risk to Marines.

D. LITERATURE ANALYSIS

1. Expeditionary Force 21 Capstone

The *EF 21 Capstone* presents newly organized guidance and planning specifics for how the USMC should prepare itself for future operations in the next ten years. This document emphasizes that it does not change what Marines do, but how they do it, allowing the Geographic Combatant Commanders (GCCs) the ability to provide the right force for the right place at the right time [7]. The reinforcement of the USMC's ability to be expeditionary in purpose, to operate in austere conditions, and the ability to maintain strong partnerships with the U.S. Navy to maneuver throughout the littoral terrain to support crisis response missions are the foundation of this capstone [7]. From the history review, UGS role in Vietnam, OIF, and OEF environments were to support intelligence collections for COIN operations; *EF 21* presents a similar opportunity yet now for crisis response operations. *EF 21* displays a new plan to align its forces for geographical support, better allowing its units to focus on specific threats and terrain as well as aligning the services support structure to fit the specific needs of the GCCs [7], as depicted in Figure 9.



Figure 9. EF 21: Poised for Response, from [7]

More specific to this thesis, *EF 21* goes on to outline the new unique requirements of the warfighting functions, including that of intelligence. This section stresses the importance of intelligence related to *EF 21* to be scalable, integrated in service and joint, capable to utilizing the latest technology, be responsive, and adaptive to the GCC's needs [7]. Similar to the review of UGS doctrine, there is a strong emphasis still today placed on the increased integration of UGS into maneuver operations, as well as the intelligence tailored for the commander, or for *EF 21* the GCC. Furthermore, it highlights areas of enhancement such as sensors, fusion, integration, and analysis [7].

EF 21 holds true as a model for future operations based on the USMC's structure, the current political environment, and service capabilities. Highlighting the importance of the right force for the right job right now, this document postures the USMC to be flexible and agile for any mission or political change [7]. One element that may present challenges is the point on a need for a defined integration of Special Operational Forces (SOF) and Marine reconnaissance elements to aid capability increases and preparation of battlespace environments [7]. This topic has been well discussed and debated over the years; although logical in presentation due to the two communities many similarities, SOF has uniquely different mission sets, operate under different statutes, and have much different support networks than conventional elements. This capstone presents great guidance and focused areas for enhancement, yet it only contains one comment regarding the evaluation of this capstone annually [7]. The reader is left to wonder how it will be enforced, evaluated, bolstered, and achieved throughout the next ten years. The *EF 21 Capstone* appears to be missing a detailed timeline and task list designed to hold certain representatives accountable for achieving performance-based measures underlined in this document, signed by the Commandant of the Marine Corps. If such a task list does exist, it should be listed in the capstone or in an appropriate annex to instill faith in the reader that there is a plan in place for detailed and successful execution.

EF 21 serves as the charted pathway for the USMC's future conduct of operations, mindset, and guidance for the planning and training of forces. The section on intelligence presents several key tenants and issues that need to be addressed to foster progression in commensurate levels. Related to UGS, the points on integration, sensor

requirements, networking, upgrades, and fusion relate heavily to this thesis [7]. To better fuse intelligence with operations, to become more integrated and persistent, to lead to better analysis and dissemination of information, UGS can aid in all of these aspects, given accurate credit and consideration. Although this document tasks the USMC Intelligence Community to define the specifics, *EF 21* calls for increased use of, advanced capabilities in, and new methods of employment for both UGS and ground reconnaissance units. In response, Chapter III explores integration of UGS with ground reconnaissance units, advanced equipment for ground PISR missions, and unit capabilities to support *EF 21*.

2. Marine Corps Intelligence Surveillance Reconnaissance Enterprise Roadmap

The *MCISR-E Roadmap* establishes the framework for service level guidance toward the progression and integration of intelligence throughout all the other warfighting functions to support future operations to 2025 and beyond [11]. Although developed as an annex to the *Marine Corps Campaign Plan for 2025*, developed in 2010, this document now falls under *EF 21*. This current version has updates from 2012, and there has recently been a new *MCISR-E Plan 2015–2020* published, however for the purpose of this thesis the 2010 version will be the main document analyzed due to its structure and detail. The guidance in this roadmap is followed by tasks, with associated timelines to hold respective agencies accountable for the progression of newly established upgrades for the USMC intelligence community [11]. Most notably, this roadmap gives clear intent toward the upgrades of systems, technology, and the integration of both for intelligence collections and analysis. Following which, this roadmap concludes with a well-organized display of its concepts as subsets to the core components of the *Marine Corps Campaign Plan for 2025*, simple in design yet speaks volumes when analyzed in respect for the execution of higher headquarters intent.

The concept of MCISR-E and this roadmap emerged in a time when the USMC was shifting to new roles and battling new responsibilities with an undetermined future. When the guidance came, this roadmap was formed and came with it the task list, able to hold elements accountable to see this plan through completion, with several opportunities

for evaluations and modifications [11]. However, there is no mention of ground reconnaissance, its future changes, advancement of roles, or organizational structure changes. This document highlights that Headquarters Marine Corps (HQMC), Plans Policies and Operations (PP&O), has the MCISR-E full support, but it never states for what it has support, nor does it give any intent under which PP&O could make reference [11]. If ground reconnaissance is to be a subset of intelligence in reality and not just on paper than the intelligence community needs to take greater ownership of this element. One element that is inconclusive in this document is the establishment of the Battlefield Surveillance Company (BSC) [11]. The roadmap states that the BSC will be developed from existing structure to integrate UGS with moving target indicators, but it never really states why. This combination of Intelligence Collections means has been done to a limited a degree in the past, but when this document references the creation of a new force with state of the art technology, several questions arise as to the cause, need, justification, and timing of the task.

This document harnesses a strong relationship with the role of UGS in the USMC because of it is clear, pivotal, well-structured guidance from the USMC's Director of Intelligence. Discussions regarding the importance of technological advancements for intelligence, development of a BSC for each intelligence battalion, and the role and importance of PISR for today's intelligence collections operations all set conditions for the advancement and development of UGS and UGS employment concepts in the today's service [11]. The MCISR-E operational concept graphic, depicted in Figure 10, shows the use of PISR forward deployed, as well as ground reconnaissance and MASINT, representing ground reconnaissance units and GSP with UGS respectfully.

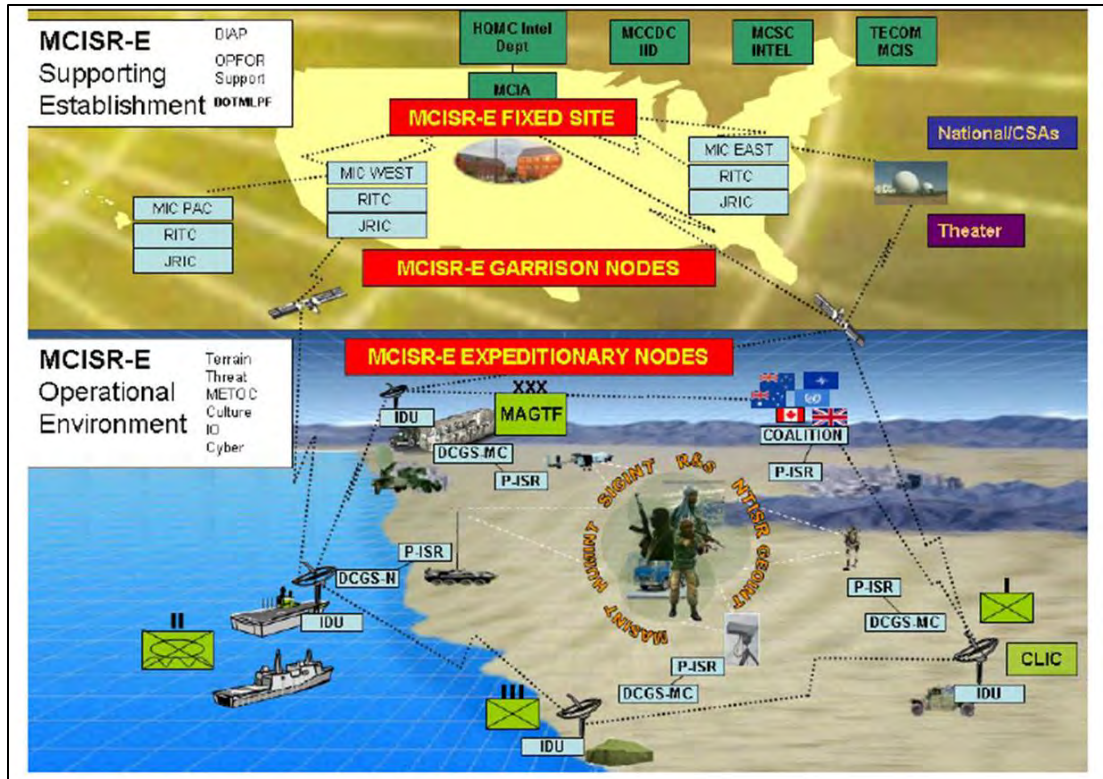


Figure 10. MCISR-E Overview, from [11]

Due to their depiction in the Figure 10, one can infer that ground reconnaissance and UGS are crucial elements to the future of intelligence operations in MCISR-E. Chapter III of this thesis analyzes the BSC construct, new UGS and UGS employment techniques, and the incorporation of ground reconnaissance units for completion of the guidance for these specific areas outlined in the MCISR-E Roadmap.

3. Mobile Situational Awareness Tool: UGS Based Remote Surveillance System

The referenced thesis explores the use of newly developed cellphone based technologies and emerging UGS capabilities to assist in Listening Post/ Observation Post (LP/OP) operations, an infantry force protection measure that is as old as warfare itself [12]. The two USMC combat arms officers address this problem through the design of the Mobile Situational Awareness Tool (MSAT) as a technological solution to the physical LP/OP problem, with the MSATs implementation and testing concluding their analysis and findings [12]. Exploring the option of enhancing human resources with

devices, and straying outside the current USMC program of record for UGS, this merger of current wireless technology with state of the art UGS for combat operations is a unique direction that sparks several possibilities and promising options for UGS advancements. Although this thesis is more technical than the other two previous reviewed literature works, it proposes the union of technology with military missions, serving as a thought-provoking example for possible upgrades to current USMC UGS for the *EF 21* and MCISR-E demands.

The most potent aspect of this thesis is how it explores the use of UGS to solve combat operations maneuver warfare problems, to use technology to augment the employment of soldiers, and to optimize the use of equipment for reduction of risk to personnel [12]. Although the thesis references the USMC's TRSS, it analyzes the equipment noted in the USMC publication and technical manuals, which is dated [12]. This thesis does not explore the realm of UGS equipment that the current fleet units have in their possession, nor does it discuss the equipment tested for future fielding by the MARCORSYSCOM. One area that could use more explanation is why the MSAT technology was chosen for research and analysis. Although well documented and tested in this thesis, the use of cellular and WiFi wireless technology in austere conditions may prove difficult for USMC operations [12]. The use of MSAT to support infantry operations is well researched in this thesis; however, the use of MSAT to support intelligence collections is not. TRSS and UGS employment is traditionally an intelligence collections field, although utilized for force protection missions quite often; it creates several ripple effects regarding asset management: if you are using your intelligence collections assets for force protection missions, then what are you using for your intelligence collections missions?

This thesis is extremely valuable to the future advancements of UGS and UGS employment because it explores new possibilities for technological integration with modern day operations. This research is unique to the establishment of a WiFi network for use in combat operations and one networked with UGS for a PISR capability. Evaluation of this technology, compared to existing and currently acquired equipment for the USMC, will present a strong argument for advance research in this focused direction.

One of the most frustrating situations for military professionals is to see civilian use of everyday modern technology while a similar capability for the military is bulky, rustic, cumbersome, and not user friendly. Here we have an example of cell phone based technology that can be utilized to advance the warfighters capabilities for PISR operations in hostile environments.

E. CONCLUSION

As technology continues to advance, and the world continues to adapt, the USMC will consistently require new and innovative ways to aid in intelligence collections in support of combat operations as well as humanitarian missions. The use of UGS in future warfare especially that of USMC expeditionary operations for crisis response missions, is virtually limitless. Analysis of the *EF 21 Capstone* and the *MCISR-E Roadmap* stress that the USMC's intelligence community demands adoption or adaption of new and emerging technologies utilized to reduce risk on the battlefield. The MSAT thesis opens the reader's eyes to possibilities while modeling the use of current cell phone technology used in UGS for LP/OP missions. The literature, doctrine, and history all show how the use of sensors for ground surveillance has vast potential when planned, employed, and managed effectively. Advanced UGS in the hands of capable ground reconnaissance Marines possess a unique capability to employ the most current technology for ground surveillance missions to enhance asset management and increase situational awareness. The literature analysis of this chapter, combined with the research collected in Chapter III, set the stage for the development of the system engineering concept design for Chapter IV, highlighting the importance and relationship of these chapters.

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III. RESEARCH ANALYSIS

A. INTRODUCTION

This chapter explores the research conducted relative to units that use UGS and certain technologies associated with UGS to support intelligence collections missions for *EF 21*. This research, combined with the analysis of the key literature pieces in Chapter II, serves as a basis for the systems engineering analysis in Chapter IV, which is to assess ways to improve the use of UGS in the USMC for *EF 21*. The USMC's operating forces are divided into three Marine Expeditionary Forces (MEF), Marine Special Operations Command (MARSOC) and Marine Forces Reserve (MARFORRES). The units that use UGS are the intelligence battalions and reconnaissance battalions, which one of each support the MEFs and MARFORRES while an additional Intelligence Battalion support MARSOC, as shown in Figure 11.

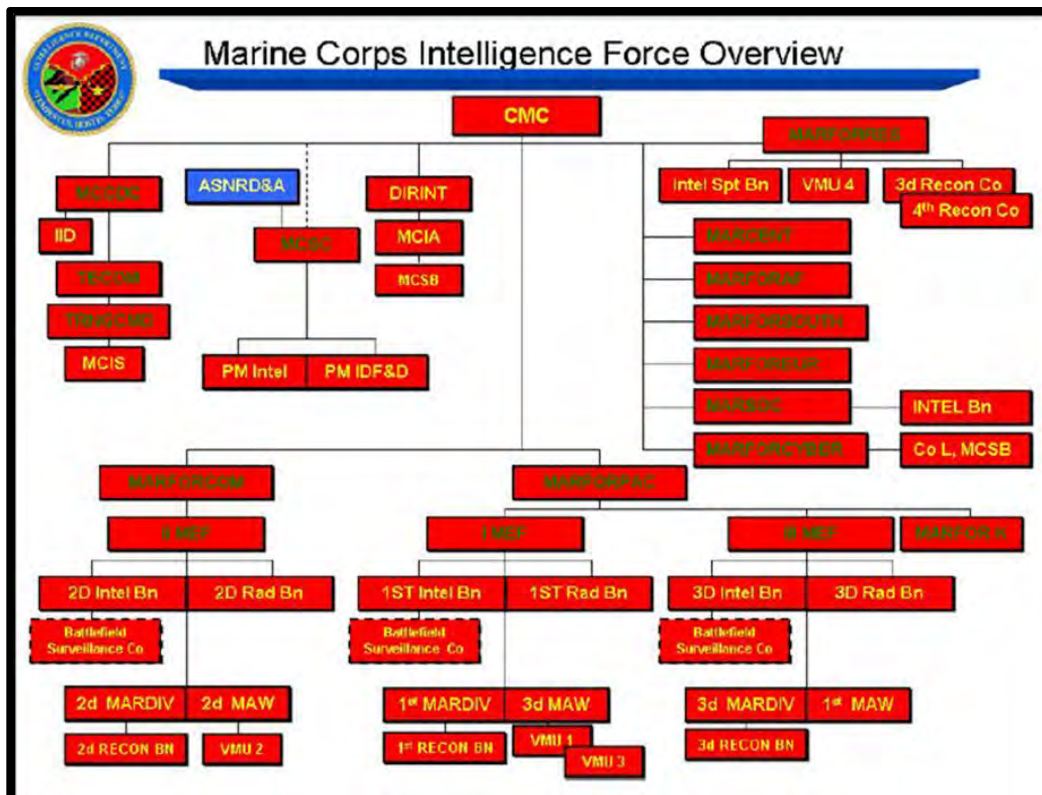


Figure 11. Marine Corps Intelligence Overview, from [11]

The intelligence battalions have owned and managed UGS Marines since the 1980s. The reconnaissance battalions employed UGS for the USMC during the Vietnam War, and since then have always been capable of and ready to employ UGS in support of combat operations. The intelligence battalions have been using TRSS equipment since the 1980s; however, other units have purchased and employed UGS of various types to support their own specific intelligence collections desires. Additionally, the military purchases, tests, and employs COTS equipment to support surveillance operations of various types. This chapter will evaluate the current units that use UGS, and current UGS to assess their level of functionality and readiness to support new demanding intelligence collections missions for *EF 21*. For the units, this chapter will describe and compare the UGS specific capabilities of the USMC's intelligence battalions and reconnaissance battalions, to include their Marines. For the UGS technologies, this chapter will describe and compare the UGS associated with TRSS, COTS equipment, and the DARPA ADAPT UGS to determine which technologies or combinations thereof will best support the USMC for *EF 21* intelligence collections. This chapter is a summarization of research essential to the associated UGS units and technologies to be applied to a system engineering analysis solution for advancements in the UGS field to support *EF 21*.

B. ORGANIZATIONS

This section will review the key common topics of the USMC's UGS employing units.

1. Intelligence Battalions

The USMC currently has four active duty intelligence battalions and one in reserve that is known as the Intelligence Support Battalion for their primary role is as Intelligence enablers and augmentations. Minus the one intelligence battalion with Marine Special Operations Command (MARSOC), each of the units contains one GSP. The mission of the intelligence battalion is to

plan and direct, collect, process, produce and disseminate intelligence, and provide counterintelligence support to the MEF Command Element, MEF Major Subordinate Commands, subordinate Marine Air Ground Task Forces (MAGTF), and other commands, as directed. [13]

The intelligence battalions are currently the only unit in the USMC that have UGS organic to their authorized Table of Equipment and is the only unit in the DOD that has Surveillance Sensor Operators, service members solely dedicated to the employment and emplacement of UGS. Recently, within the guidance of the *MCISR-E Roadmap*, the intelligence battalions created the BSC to provide additional leadership and oversight to the development and execution of UGS and MASINT operations for the MEFs. This new BSC structure places key intelligence subject matter experts in leadership and advisory roles over the GSPs, as well as Intelligence Specialists at the squad level for the GSPs, as shown in Figure 12.

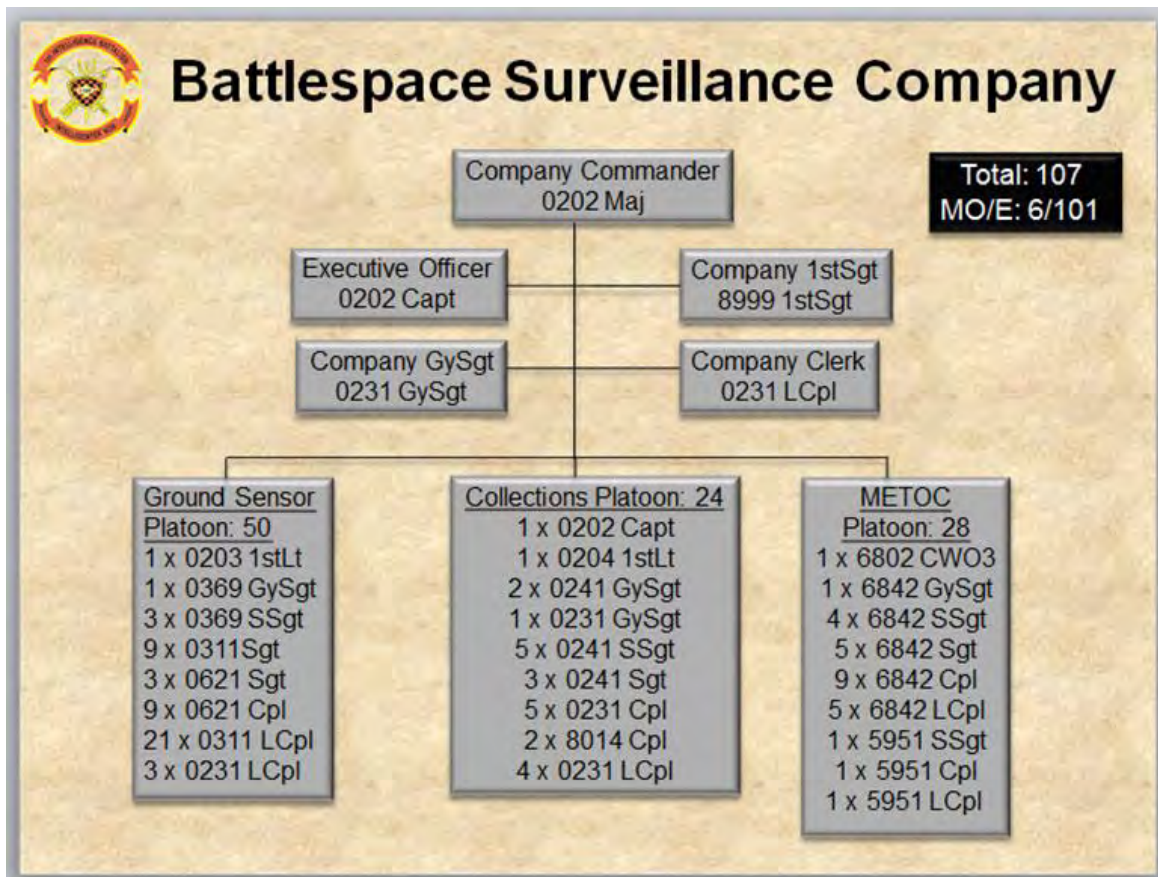


Figure 12. Battlespace Surveillance Company Table of Organization, from [14]

Each GSP contains three Sensor Employment Squads (SEs), with each squad containing two Sensor Employment Teams (SETs) and each SET containing six Marines.

The SETs are capable of conducting limited maneuver operations on their own, as most missions will require support for insert and extract of the SET and additional security elements while conducting operations in hostile areas. Although the SETs could theoretically operate as their own maneuver element, training requirements and recent history do not support this theory. In relation, this could prove difficult for the SETs and GSPs to support independent operations in hostile areas for *EF 21* intelligence collections missions if they require extensive support for UGS emplacement and recovery missions.

a. Unit Training

As per the Intelligence Training and Readiness (T&R) Manual, the Intelligence Battalions contain the one and only battalion level Mission Essential Task (MET) for UGS, which is to conduct ground sensor operations [15]. For this single battalion level MET, it contains one platoon level UGS specific task, four squad-level Intel-related tasks, and one team level UGS specific task. Relative to surveillance operations, this is a very small number of associated tasks and sub tasks for operations that risk the employment of Marines in hostile areas; however, this is not necessarily a negative factor for an abundance of tasks may only complicate the issue. Additionally, several infantry training and readiness events need to be factored into the individual training events for the Surveillance Sensor Operators.

b. Individual Training

As per the current MOS Manual, the MOS of 8621: Surveillance Sensor Operator is one of three MOSs in the USMC with UGS related tasks, but is the only MOS specific to UGS ownership and monitoring. The summary of this MOS states, Surveillance Sensor Operators inspect, install, operate, and perform operator maintenance on surveillance equipment prior to and after employment [16]. Their duties are listed as:

1. Prepares various types of remote sensor surveillance devices for air and hand emplacement methods in areas previously determined.
2. Monitors and interprets sensor devices by reading out audio and visual transmissions.
3. Plots sensor string locations on maps and overlays.
4. Makes recommendations to and assists the intelligence officer in selecting areas, routes, and specific sites to be employed.

5. Provides timely and accurate data concerning enemy location, direction, speed of movement, and strength.
6. Recommends appropriate action and reaction to be taken and calls fire missions on valid targets acquired.
7. Assists in testing and evaluating new sensor surveillance equipment and ancillary devices.
8. Provides surveillance equipment instruction. [16]

Additionally, the MOS Manual highlights that Surveillance Sensor Operators may come from a variety of MOS backgrounds (intelligence, infantry, and communications), and that it is a secondary MOS, which means Marines will only do this for a select time frame in their career and will then have to return to their primary MOS [16]. Marines that meet the prerequisites of the primary MOS, security clearance, and graduation from the Surveillance Sensor Operators Course (SSOC) in Dam Neck Virginia will then receive the 8621 MOS. To assess the current potential of the Surveillance Sensor Operators to support UGS operations for *EF 21*, analysis of this MOS will focus on the MOS 0300 Basic Infantryman and MOS 0311 Rifleman skills in addition to those of the Surveillance Sensor Operators. Although the fields of MOS 0231: Intelligence Specialist and MOS 0621: Field Radio Operator can also achieve the MOS 8621, the Infantry MOS provides a better analysis of field craft and tactical skills, which make up the majority of the GSPs and will be in high demand to meet the expectations of *EF 21* intelligence collections missions. Each Rifleman must first go through MOS 0300 Basic Infantryman training at the School of Infantry (SOI), which is why this is included in the quantitative depiction and qualitative analysis of the Surveillance Sensor Operator. Specific to the Surveillance Sensor Operator, the training and readiness events used for analysis will be the individual events, 1000 level and 2000 level, as shown and described in Figure 13.



Figure 13. Training & Readiness Event Levels, from [15]

Analysis of the 1000 level training and readiness events for the MOS 0300 is not needed for this thesis as both the Surveillance Sensor Operators and MOS 0321s Reconnaissance Man Marines go through this training. Table 3 shows the select 1000 and 2000 level training and readiness events for the MOSs 0300/0311/8621 that apply specifically to the Surveillance Sensor Operators.

Table 3. Surveillance Sensor Operator Training Events List, after [15]

Surveillance Sensor Operator		
MOS / T&R Events	Type	Quantity
0311 / 1000 Level	Defense	1
	Demolitions	1
	Weapons	4
	MOUT	3
	Offense	1
	Patrolling	1
	Total	11
0300 / 2000 Level	Combat Hunter	8
	Communications	6
	Demolitions	1
	Fire Support	5
	Small Unit Leadership	1
	Weapons	6
	Mobility	2
	Patrolling	6
	Training	3
	Tactical Vehicles	10
	Total	48
0311/ 2000 Level	Defense	6
	Demolitions	1
	Intelligence	4
	Weapons	10
	MOUT	2
	Offense	7
	Patrolling	3
	Training	2
	Total	35
8621 / 2000 Level	Communications	1
	Planning	2
	Dissemination	3
	Sensors	11
	Security Manager	1
	Total	18
Overall Total Events		112

Note that out of all the 112 individual training and readiness events for the MOS 8621, only 11 (9.8%) are specific to UGS, with another seven (6.3%) closely related, and an additional four (3.6%) training and readiness events specific to intelligence [15].

Although the quantity may be low, the quality is significant as these numbers exceed all other units for UGS related tasks. In addition, these UGS specific tasks have been thoroughly evaluated and updated over the past ten years to ensure quality control. Additionally, tactical skill sets to support maneuver operations for the emplacement implant and recovery of UGS to support *EF 21* type missions include ten patrolling training and readiness events (8.9%), eight events for combat hunter (7.1%), seven events for communications (6.25%), 20 events for weapons (17.9%), and ten events for tactical vehicles (8.9%) [15]. With these statistics, Surveillance Sensor Operator training and readiness events include 22 events (19.6%) specific to UGS employment and 55 events (49.1%) specific to the tactical demands of conducting UGS missions to support *EF 21* intelligence collections operations [7], [15]. Additionally, 35 events (31.3%) support individual MOS 8621 training and readiness actions for *EF 21* related missions [15].

2. Reconnaissance Battalions

The USMC currently has three active duty reconnaissance battalions, one supporting each Marine Division, and one reserve battalion supporting 4th Marine Division, MARFORRES. Additionally, there are three active-duty force reconnaissance companies with one supporting each MEF and two reserve force reconnaissance companies. The mission of the reconnaissance battalions or elements thereof, is

to conduct advanced force operations, underwater reconnaissance, amphibious reconnaissance, ground reconnaissance, surveillance, battle space shaping, and specialized limited scale raids in support of the Marine Division, Marine Expeditionary Force, or designated MAGTFs[1].

The mission of the force reconnaissance companies relatively the same as that of the reconnaissance battalions, only difference being that the force reconnaissance companies support the MEF, other MAGTFs, or the Marine component of a Joint Force or Joint Task Force [1].

Both ground reconnaissance units contain the following METs:

- MET 1: Provide task-organized forces.
- MET 2: Conduct amphibious reconnaissance and surveillance.

- MET 3: Conduct ground reconnaissance and surveillance.
- MET 4: Conduct battlespace shaping operations.
- MET 5: Conduct specialized limited scale raids.
- MET 6: Conduct specialized insertion and extraction.
- MET 7: Establish means for command and control. [17]

The structure of the reconnaissance battalion (as displayed in Figure 14) contains four companies, one of which is a headquarters company while the other three are ground reconnaissance companies, each containing four reconnaissance platoons. The force reconnaissance companies each contain one headquarters platoon and four force reconnaissance platoons. The active-duty force reconnaissance companies are in an Administrative Control (ADCON) relationship with their geographically located reconnaissance battalion, which implies that they rely on the reconnaissance battalions for extensive administrative and logistical support. The force reconnaissance companies also remain in an Operational Control (OPCON) status to their respective MEF, always available for tasking and support. The reserve force reconnaissance companies remain in an OPCON and ADCON status under MARFORRES. Each reconnaissance platoon, from both the reconnaissance battalions and force reconnaissance companies, consists of three teams of six Marines and all teams are capable of serving as independent maneuver elements in support of combat operations.

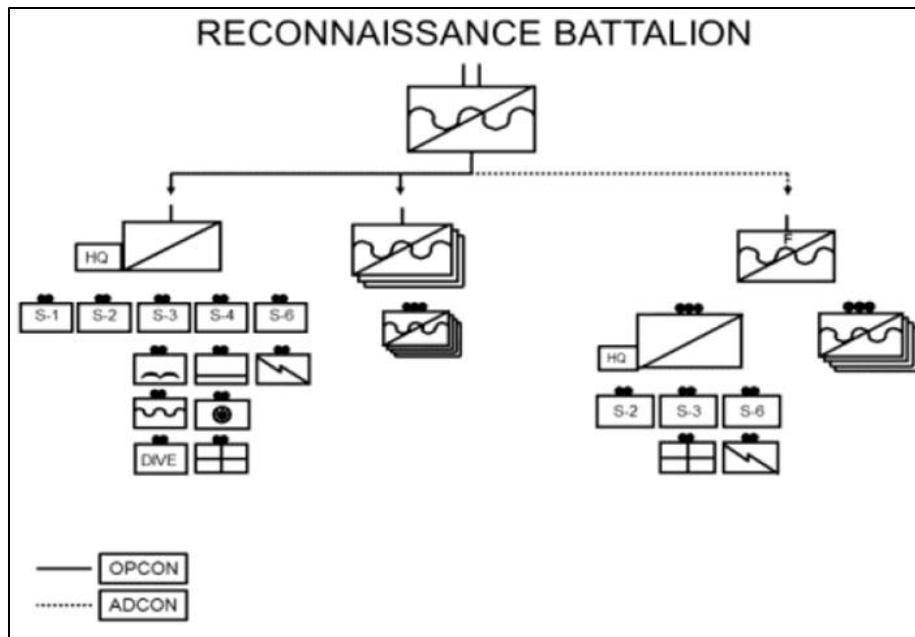


Figure 14. Reconnaissance Battalion Organizational Chart, from [1]

a. Unit Training

The reconnaissance battalions are responsible for two training and readiness events specific to the employment of UGS, one of which is a squad level event and the other is a platoon level event, both of which are worded as to conduct sensor implant and recovery [17]. These events do not highlight the requirement to monitor nor maintain the UGS. As needed and when tasked to do so, the GSPs will train infantry and reconnaissance Marines in the use of the UGS, allowing them the ability to implant and recover the UGS. Additionally, the *Reconnaissance Training and Readiness Manual* lists the core capabilities for key billets, nine of these billets contain the task to implant and recover UGS. In relation, Appendix C (C-1 to C-16) of the *Intelligence Training and Readiness Manual* breaks down specific intelligence training and readiness events that support the METs of the GCE battalions, which is a great training reference for commanders and intelligence officers to task and train their intelligence sections accordingly. With the *Intelligence Training and Readiness Manual* being the primary source of UGS specific events, not one of these events is specifically tasked to any of the reconnaissance battalion METs. This is important because it shows no direct relationship or tasking for the reconnaissance battalion or force reconnaissance companies

intelligence sections to support or coordinate UGS training or missions with the GSPs. This role would then be executed by the unit's operations officers, should it be needed. In summary, the reconnaissance battalions and force reconnaissance companies have six complex and intense METs to train for, leaving little room for untasked UGS training under current training and operational standards.

b. Individual MOS Training

The majority of the reconnaissance battalion's Marines are of the MOS 0321: Reconnaissance Man. The MOS Manual summarizes this MOS, stating that

the Reconnaissance Man is an infantry Marine skilled in amphibious reconnaissance and ground reconnaissance. In addition to basic infantry skills, he possesses proficiency in scout swimming, small boat operations and refined observation, scouting, patrolling and long-range communications skills. Reconnaissance Men receive advanced training as Static Line and Military Free-Fall Parachutists and Jumpmasters, as well as Combatant Divers and Diving Supervisors. [16]

As a Reconnaissance Man completes the advance Airborne and Combatant Diver training, he will receive additional MOS designators (such as the MOS 0326: Reconnaissance Man, Parachute and Combatant Diver Qualified), however for the purpose of this thesis, all skill sets will be covered in reference to the MOS 0321 field. Timing and career progression dictates when a Reconnaissance Man will complete the SPIE schools. Similar to the table for the Surveillance Sensor Operators, Table 4 shows a breakdown of the individual training and readiness events for the Reconnaissance Man.

Table 4. Reconnaissance Man Training Events List, after [17]

Reconnaissance Man		
MOS / T&R Events	Type	Quantity
0321 / 1000 Level	Amphibious Recon	14
	Collections	23
	Communications	14
	Conditioning	4
	Demolitions	8
	Ground Recon	22
	Intelligence	6
	Medical	15
	Photography	6
	Planning	9
	Raids	12
	SERE	24
	Shaping	4
	SPIE	18
	Surveillance	9
	Weapons	25
	Total	213
0321 / 2000 Level	Amphibious Recon	4
	C2	1
	Collections	24
	Demolitions	8
	Ground Recon	11
	Intelligence	2
	Medical	3
	Planning	3
	Raids	3
	Shaping	10
	SPIE	16
	Surveillance	6
	Weapons	48
	Total	139
Overall Total		352

The Reconnaissance Man MOS contains over three times as many individual events as that of the Surveillance Sensor Operator, several of which are related to intelligence, communications, and the operation of advanced technical devices. These fields, along with weapons skills and tactics are all utilized in UGS implant and recovery operations, especially in support of operations such as those related to *EF 21*. However, there is not one individual event specific to UGS for the MOS 0321. This MOS has several similar skills that match or exceed those of the UGS specific events for the Surveillance Sensor Operators, many of which require advanced tactical and technical skills. This is not necessarily negative, for the task to conduct UGS operations is in the platoon and squad level events. One possible assessment is that it is not needed because of the Reconnaissance Man's average level of exposure to advanced technical equipment such as new radios, computers, and fire control systems, would imply that if a mission arose for UGS, because of their other training in similar fields the individual would be quick to learn. Thus, leaving the employment of UGS as a unit task for the reconnaissance battalions, this is contrary to the Surveillance Sensor Operator's field that contains both unit and individual training and readiness events pertaining to the SME role for UGS. Reconnaissance Men are true tactical experts, able to use infantry, intelligence, and communications skills with stealth techniques to operate in high-risk conditions. Several of these factors could be applied to the UGS community to expand their support reach for *EF 21*.

3. MOS Comparative Analysis

Now that the Surveillance Sensor Operator and Reconnaissance Man MOSs have been defined, the next step is to compare and contrast the two MOSs to evaluate which one can best support UGS operations for *EF 21* intelligence collections missions. Evaluation of both MOSs creates certain categories for the 1000 and 2000 level training and readiness events, as displayed in Table 5.

Table 5. Training and Readiness Event Grouping, after [15], [17]

T&R Event Grouping				
	MOS 8621		MOS 0321	
Groups	T&R 1000 / 2000 Level Categories	Quantity	T&R 1000 / 2000 Level Categories	Quantity
Weapons	Weapons, Demolitions	23	Weapons, Demolitions	89
C3	Communications	7	Communications, C2	15
Intelligence	Intelligence, Dissemination, Sensors	18	Intelligence, Collections, Photography, Amphibious Recon, Ground Recon, Surveillance	127
Maneuver	Offense, Defense, MOUT, Patrolling, Combat Hunter, Tactical Vehicles, Mobility, Fire Support	55	Raids, SPIE, SERE, Medical, Shaping	105
Readiness	Planning, Training, Small Unit Leadership, Security Manager	9	Planning, Conditioning	16
Total		112		352

The main groups of training and readiness events for evaluation are Weapons; Command, Control, and Communication (C3); Intelligence; Maneuver; and Readiness. The Reconnaissance Man field contains almost twice as many training and readiness events for each group, with four times as many events for the Weapons category and six times as many events for Intelligence. Refer to Figure 17 for the displayed quantitative comparisons of the two MOSs.

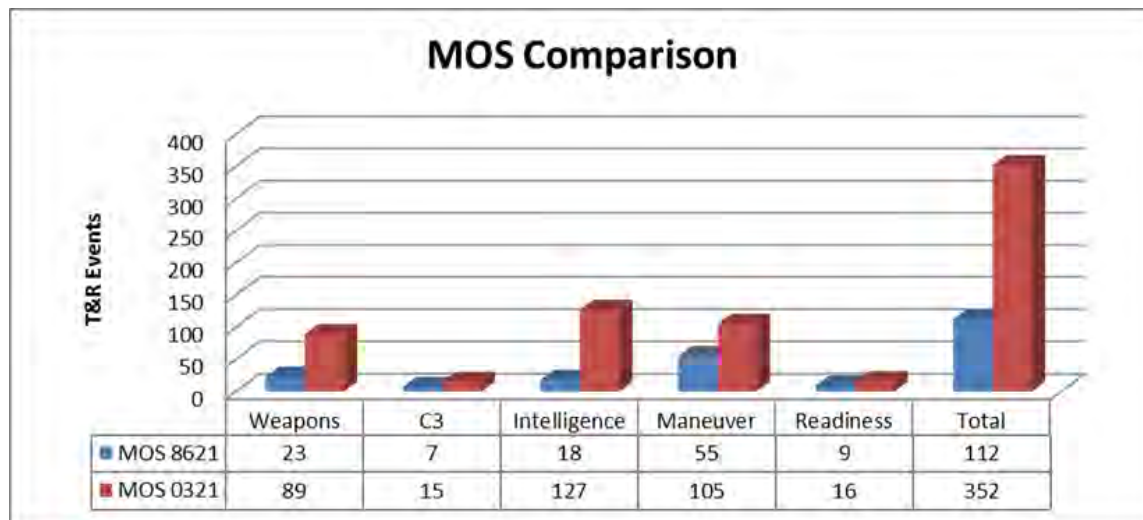


Figure 15. MOS Comparison Graph, after [15], [17]

This data set indicates that the average Reconnaissance Man is more skilled in advanced maneuver and intelligence collections than the average Surveillance Sensor Operator. The reality is that no single unit can train each of its Marines in every single one of these events; even though the training and readiness manuals define the minimum number of events Marines should train to prior to combat operations. Additionally, HQMC will prioritize to which events a unit will train, which can vary between the battalions due to geographical location and assigned missions. With *EF 21*, each battalion would have different training requirements due to its geographical assignments. Assessing the two MOS shows that even though Reconnaissance Man field does not have any individual level training and readiness events specific to UGS, they have several similar events and many more events of increased complexity requiring smart and mature Marines. Additionally, there are almost nine times as many Reconnaissance Men as there are Surveillance Sensor Operators in the USMC, and the Reconnaissance Man MOS is permanent, unlike Surveillance Sensor Operators. This is important because it shows the demand signal of the two MOSs, which also justifies a specific training and readiness manual for reconnaissance Marines and units while Surveillance Sensor Operators share training and readiness manuals with the Infantry and Intelligence communities. Contrary to the comparison of capabilities, the average Reconnaissance Man will have several tasks and training requirements to complete as well as high-risk training and SPIE

methods that require a significant amount of time. The average Surveillance Sensor Operator will be allowed to focus solely on UGS and UGS missions alone, leading them to become true subject matter experts for UGS in the USMC.

C. TECHNOLOGY RESEARCH

We next analyze some of the current technological equipment used with UGS in the commercial and DOD fields. This chapter explores the types, detection ranges, communications ranges, software applications, and weights associated with these UGS. The USMC currently owns and operates the TRSS, which contains various UGS and communications monitoring equipment for the GSPs. The leading COTS vendor for UGS is McQ, producer of UGS for intelligence collections and force protection utilized by several government agencies and civilian companies alike. The Defense Advance Research Project Agency (DARPA) has developed special UGS known as the Adaptable Sensor System (ADAPT) to serve in an innovative method as nonlethal mines. Each of the three select types of UGS systems are described in this chapter, as well as some other related surveillance equipment. Following is a comparison and analysis of these UGS in relation to their current relevance and tactical application in support of *EF 21* intelligence collections missions.

1. TRSS Overview

The USMC has been using TRSS equipment since the 1980s, which gives great credit to the system for its ability to adapt to the current battlefield and receive system upgrades or new sensors, which has always been the cornerstone of its existence. The TRSS Technical Manual (TM) states:

The Tactical Remote Sensor Systems System of Systems (TRSS SoS) is a system-of-systems program to provide unattended sensors, retransmission systems, and sensor monitoring systems. TRSS are deployed and operated by Ground Sensor Platoons (GSPs) in support of the Commander's intelligence collection effort. Once deployed, the remote systems operate autonomously to provide continuous, unattended surveillance of distant areas of the battle space. TRSS are frequently employed to provide surveillance and reconnaissance in places where it is too dangerous to maintain personnel or not tactically practical to deploy other surveillance systems. Remote sensors use multiple sensing modalities and radio

communications methods to detect and report personnel and vehicle activity in designated areas of interest. All sensors are passive; detection is accomplished when target-generated energy is sensed. [18]

This quote stresses several key points addressed in previous chapters, such as the marriage between TRSS and the GSPs, that TRSS is flexible, and that it has the unique capability to conduct reconnaissance missions in areas other assets cannot. Figure 16 shows an example of TRSS employment in a complex diverse environment for advanced intelligence collections.

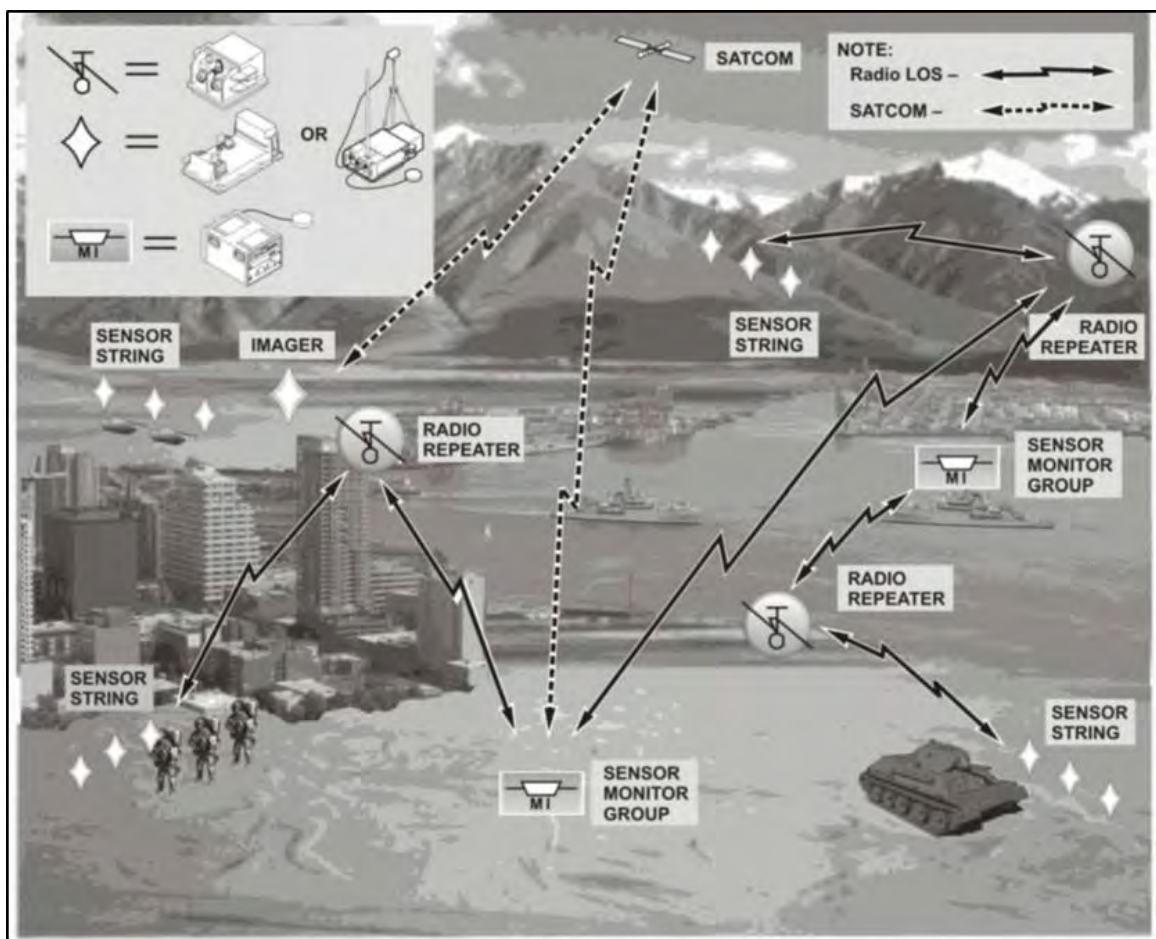


Figure 16. TRSS Theater of Operations, from [18]

This figure depicts the use of TRSS equipment in urban and rural non-permissive areas, tracking the movement of personnel and tracked vehicles, relaying signals through

multiple frequencies, with a Sensor Monitoring Group (SMG) established on a naval ship at a secure location.

a. Equipment Specifications

TRSS contains several different types of UGS in different shapes and sizes to aid in overall adaptability. The sensors include the Encoder Transmit Unit Version II (ETU-II), which is the Seismic and Acoustic (SA) UGS for the TRSS, as well as the communications device for all of the TRSS equipment except the imagers [18]. The Magnetic Intrusion Detector (MAGID) is the magnetic UGS for the TRSS, and the Infrared Intrusion Detector Version II (IRID-II) is the IR UGS for the TRSS [18]. The UGS communications signals can be relayed via the Radio Relay (RR) device, as shown in Figure 16, which allows for maximum concealment of the UGS near the objective area, and the emplacement of larger yet more powerful communications device in the RR to be emplaced further away in a more safe or concealable area [18]. The UGS data set terminates at the SMG, which is a computer system that receives and monitors all UGS data sets [18]. For the Marines in the field, the Hand Held Programmer Monitor (HHPM) allows them the ability to configure the UGS, sight in the imagers, and monitor UGS collections information from the field [18]. Figure 17 shows these different types of UGS in the TRSS family.

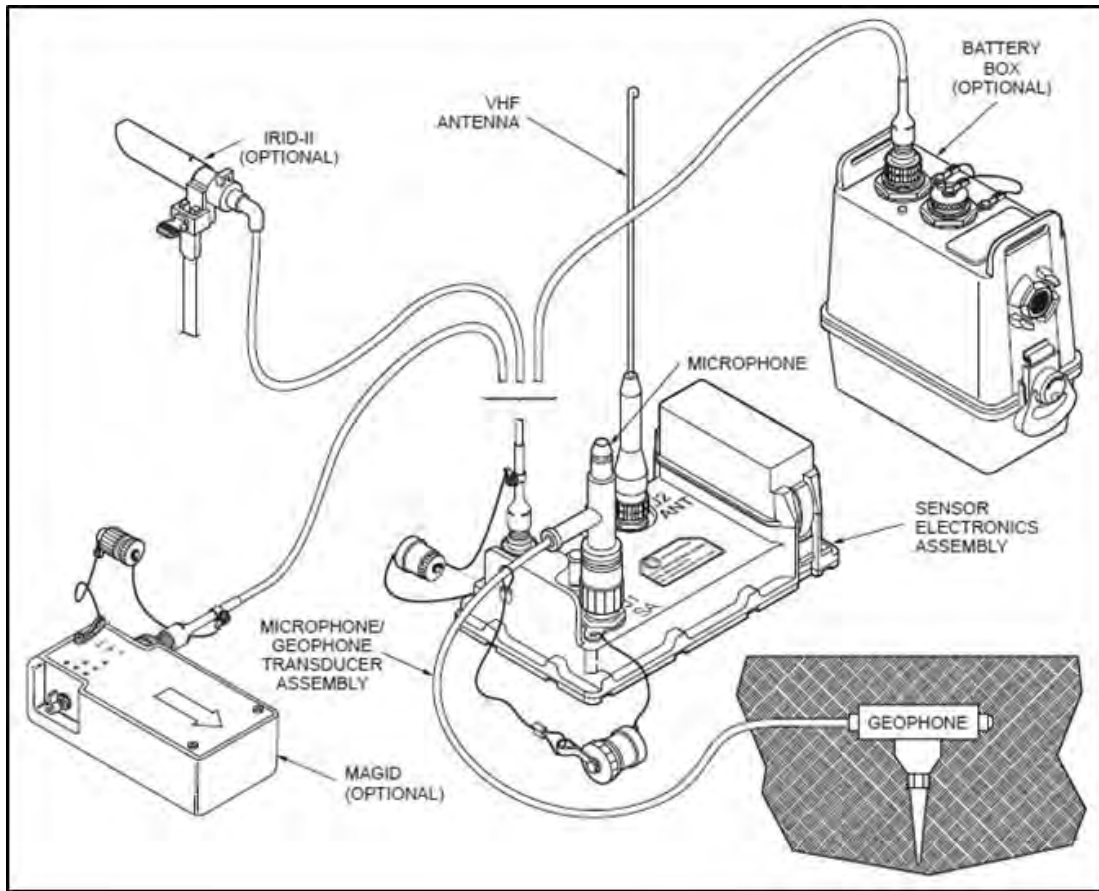


Figure 17. TRSS UGS Operational Configuration, from [18]

The battery box provides an added option for extended life for the UGS, should the tactical situation permit [18]. The geophone is the seismic spike that requires burying for proper functioning [18]. All these UGS and supporting equipment are capable of being buried for concealment and operations [18]. The UGS antennas, acoustic microphone on the ETU-II and the IRID-II lens are the only components that must remain exposed [18].

The TRSS has both a short-range imager and a long-range imager, as seen in Figure 18.

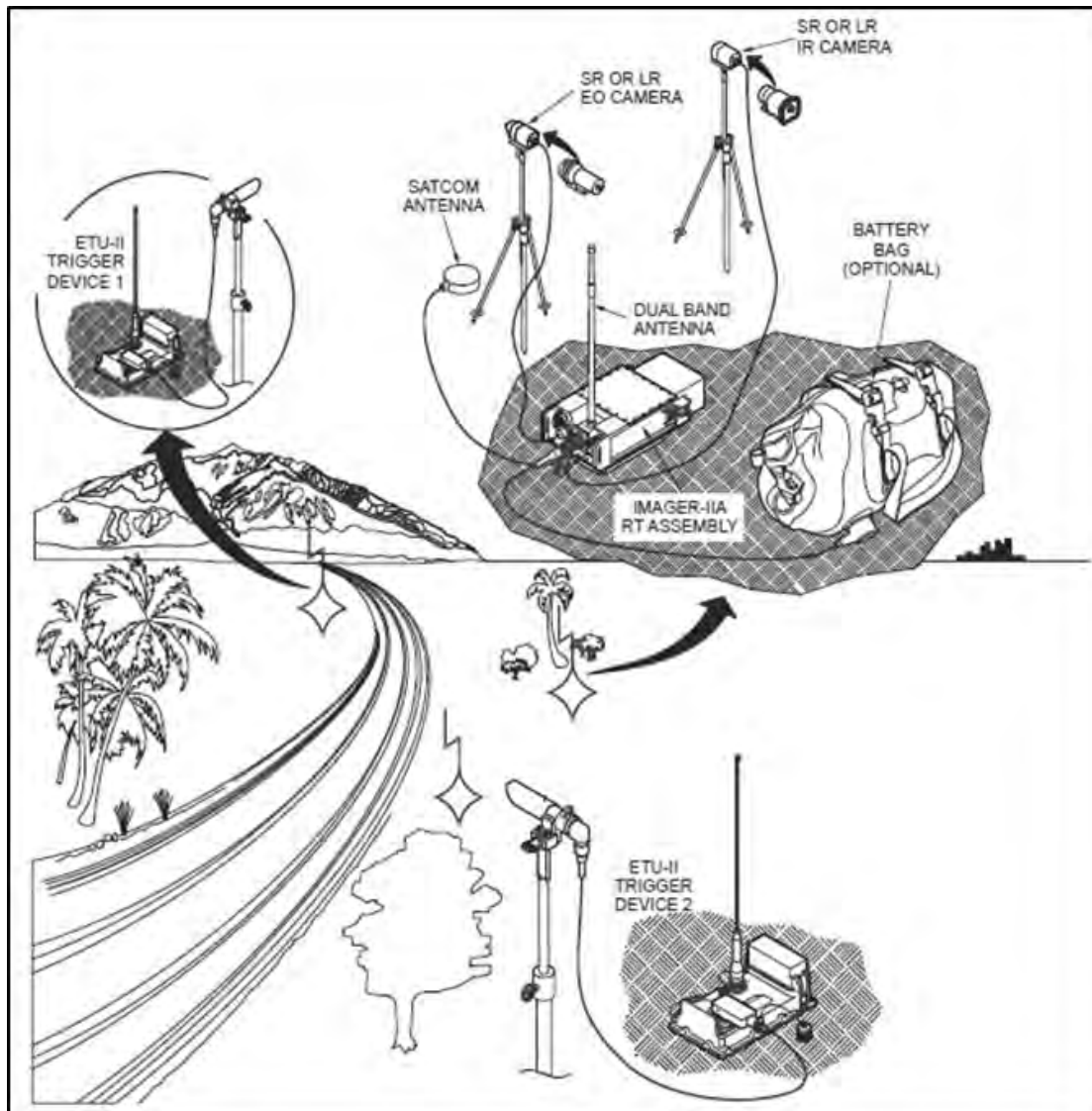


Figure 18. TRSS Imagers Operational Configuration, from [18]

These imagers are capable of operating in a variety of areas, taking still imagery but not full motion video, and being programmed to allow for cuing by the ETU-II [18]. This is a good combination of different detection capabilities that results in a creation of an image anytime the other UGS are activated, which allows the imager to go to sleep until cued to take a picture, thus saving battery life.

TRSS can communicate over both Very High Frequency (VHF) and Ultra High Frequency (UHF) channels, the latter including both line-of-sight and satellite links to aid in overall versatility for employment [18]. However, data transfer rates are limited to no

more than 9600 bits per second (bps). Figure 19 depicts the TRSS communications capabilities while Table 6 provides the specific frequency ranges supported.

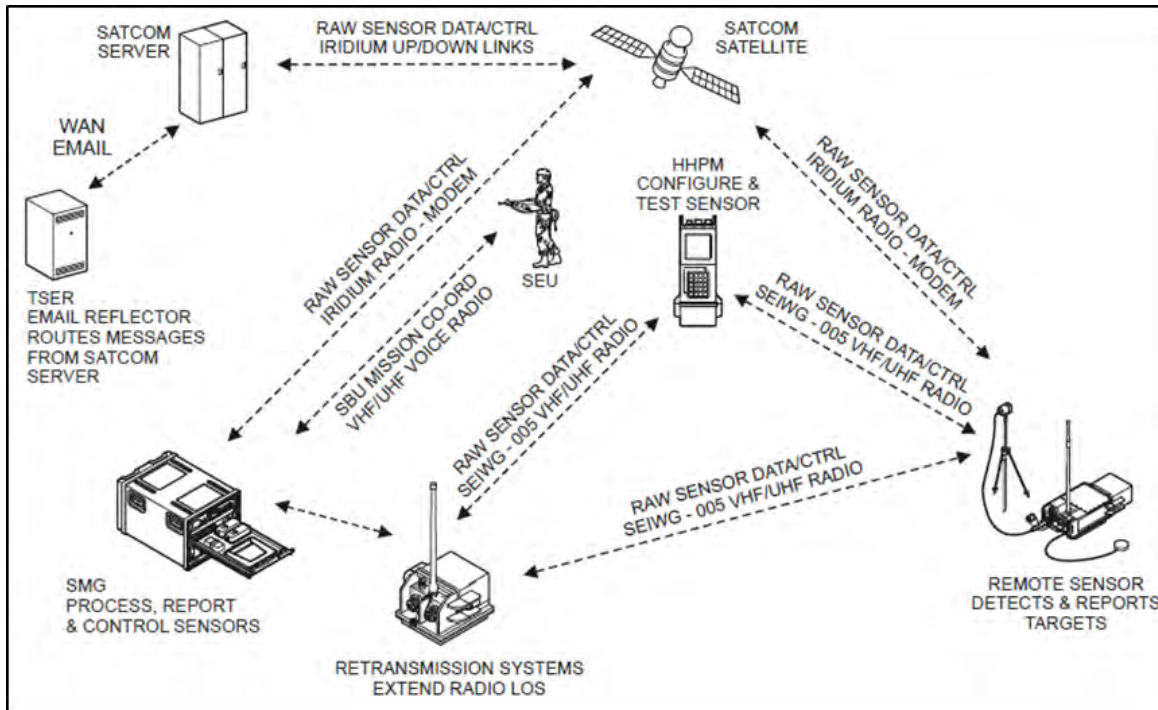


Figure 19. TRSS Device Communications Programming, from [18]

Table 6. TRSS Operating Frequency Range, from [18]

VHF RANGE: 138 to 153 MHz	UHF RANGE: 311.5 to 313.5 MHz	SATCOM RANGE: 1616 to 1626.5 MHz
# of VHF Channels @ 1200 bps - 599 9600 bps - 1198	# of UHF Channels @ 9600 bps - 41 32 kbps - 41 56 kbps - 41	# of SATCOM Channels N/A

This extent of communications capability, coupled with state-of-the-art technology, provides TRSS the ability to support a variety of surveillance missions in multiple environments for optimal efficiency in intelligence collections.

b. Employment

TRSS offers a variety of employment opportunities for intelligence collections missions despite being designed as cueing devices, which means as they collect data sets,

the personnel doing the monitoring of this data set must determine suspicious information through pattern analysis and situational awareness. This data set would then lead to the monitoring unit sending in another asset to investigate, such as a patrol from a friendly unit or a UAS to remain in a stealth role. TRSS is a durable and reliable system capable of advanced SA, IR, magnetic, and imagery intelligence collections. Figure 20 accurately depicts the communications scheme for employment, which significantly highlights the numerous possibilities for the UGS to talk to each other.

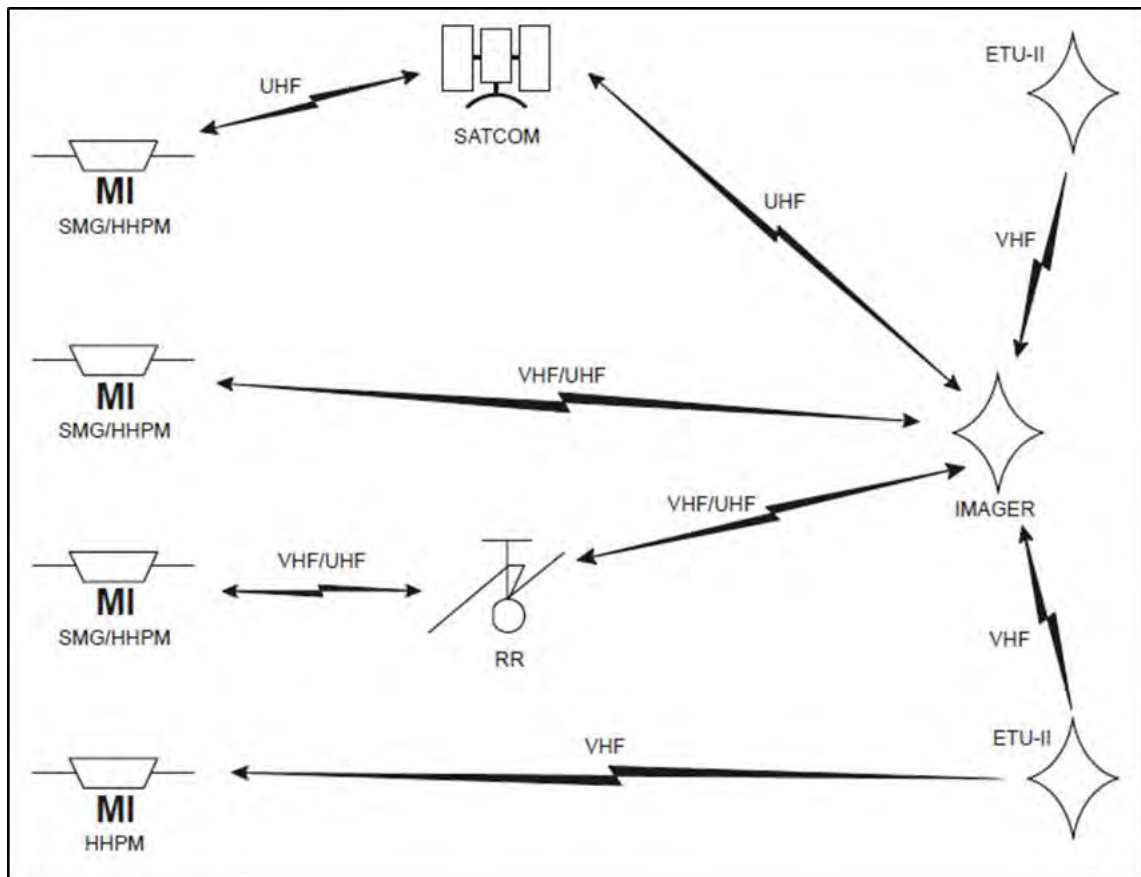


Figure 20. TRSS Sample Network, from [18]

Key factors associated with the employment capabilities of the TRSS are the weight, size, detection ranges, and battery life of the UGS. Table 7 shows the detection ranges, based on certain conditions and targets.

Table 7. TRSS Sensor Directory, from [18]

DEVICE		DETECTION RANGE (IN METERS)				CLASSIFICATIONS	OTHER
		UNKNOWN	PERSONNEL	VEHICLE			
				Tracked	Wheeled		
ETU-II SA:	low	-	0.5	2	2.5	Unknown, Personnel, Vehicle, Tracked Vehicle, Wheeled	
	medium	-	4	16	20		
	high	-	10	40	50		
MAGID:	low	N/A	4	15	15		Target Count
	high	N/A	4	25	25		
IRID-II		N/A	5 – 20	5 - 50	5 - 50	N/A	Target Count
Imager: EO Camera (SR)		N/A	10 – 150	20 - 500	20 - 500	N/A	
IR Camera (SR)		N/A	10 – 150	20 - 500	20 - 500	N/A	
EO Camera (LR) ¹		N/A	50 – 450	100 - 1000	100 - 1000	N/A	
IR Camera (LR) ¹		N/A	50 - 450	100 - 1000	100 - 1000	N/A	

¹When using long range cameras, the maximum range for vehicle detection can be increased, but requires the sensors to be placed further from the area of interest. This scenario results in reduced mission life of the system due to the cameras being powered on for longer durations. For use with the AN/PSQ-21A Imager only.

To clarify Table 7, “low, medium, and high” refer to the detection ranges for the TRSS UGS based on severely restrictive, restrictive, and non-restricted military doctrinal terrain classifications. Example being a dense urban area would be severely restricted terrain, which would result in low detections ranges, whereas the desert would be non-restrictive terrain, which would result in high detection ranges. The “unknown” sensor detection criteria is a manufactures note, stating that not all detections will be classified, and that this can occur at all ranges and conditions for all UGS based on the situation.

c. Summary

TRSS is a versatile system with unique and advanced capabilities that is rugged and user-friendly. TRSS has had a strong reputation of success over the past few years, adjusting to support a multitude of missions. The ability to use both long and short-range imagers provides an increased ability to conceal smaller devices closer to the objective, while maintaining a collections capability with greater standoff for the long-range imager. Additionally, having each of the UGS separate, or single UGS in single node vs multiple UGS in one node, allows for specific user configuration as well as selective maintenance, for if one of the UGS is bad the others are not affected and the system is still operational. TRSS UGS contain a tamper feature; if hostile forces or civilians

recover the UGS, the UGS can send a signal to the SMG and the UGS then zeroes out all stored data sets, rendering it null until it is recovered and reprogrammed.

Over the past ten years, upgrades to the TRSS communications capabilities and added imagers have aided in the UGS increased flexibility to support a variety of tactical operations. Certain UGS seem bulky and heavy at times, but overall they are adaptable and reliable.

There are some operational limitations to the TRSS. Currently, it has no Air Delivery (AD) capability. It has no radar sensor capability. It lacks the ability to integrate with digital Common Operational Picture (COP) systems. Further, it lacks a capability for remote offsite configuration from the SMG.

2. McQ Overview

One of the leading COTS UGS companies is McQ, based in Stafford, Virginia. McQ developed the OmniSense UGS, a multi-sensor encased node that was SATCOM capable and used during OIF starting in 2004. McQ is well known for using state-of-the-art technology, and, in the more recent years, has focused on designing UGS to be rugged, unique, yet small and light. McQ defines their UGS with the following characteristics:

Technical Attributes:

- Very low power sensors that provide long endurance operations with small battery supplies.
- An advanced digital architecture designed around a modular approach for working with different sensors and providing a flexible set of features.
- Integrated communications that allow digital wireless RF communications from each sensor interfaced into a variety of network architectures to relay critical data to a final destination for analysis and alarm readout.
- Advanced digital sensor processing combining algorithmic, time/frequency domain transforms, and decision logic to make informed decisions based on signal features.
- Mechanical designs that permit airdropping sensors with or without parachutes.

- Advanced image processing and data fusion with multi spectral sensors providing computer driven Situation Awareness. [19]

Like TRSS, McQ UGS can use VHF, UHF, or SATCOM; however, unlike TRSS they possess a unique WiFi capability as well. All McQ UGS use the TNet for communications, which is their own specific network system of repeaters and a base station, as displayed in Figure 21.

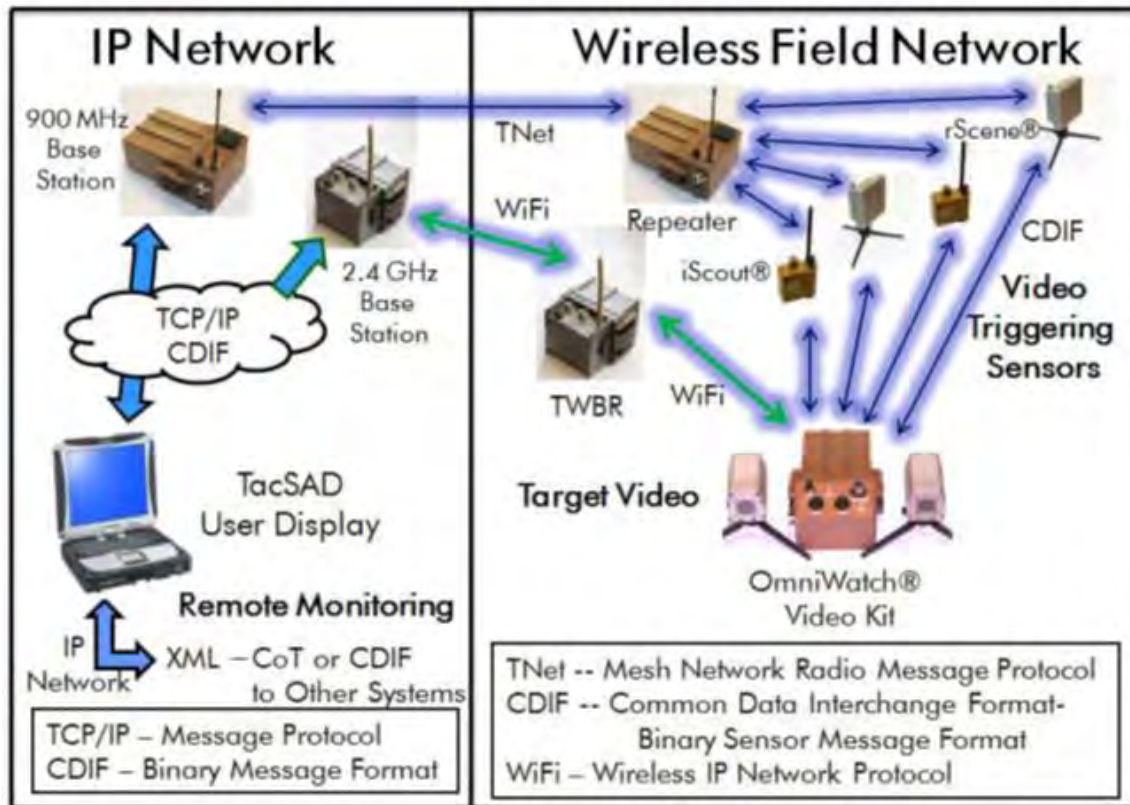


Figure 21. McQ UGS Network, from [6]

Similar to TRSS, McQ UGS are proven to be rugged, flexible, and adaptable to a multitude of mission sets, which is clearly seen in their extensive DOD, Department of Justice, Department of Homeland Security, and civilian security company customer listing. The programming and monitoring of McQ UGS at the employment site is through an android smart phone, which is much lighter, smaller, and user friendly than the TRSS HHPM. Once emplaced, McQ UGS show GPS location for monitoring and tracking. All

McQ UGS can be configured independently onsite via the android smartphone or offsite via a laptop and TNet communications components from the monitoring site. These UGS do not require burying for proper functioning, unlike the ETU-II in TRSS, which must be buried for the seismic UGS to function. All McQ UGS can autonomously interface with a digital COP system for digital battle tracking.

a. Equipment Specifications

Although the OmniSense UGS are no longer being used, McQ has developed the iScout, an encased SA, IR, and magnetic UGS much smaller, lighter, durable, and reliable than the OmniSense. With several UGS in one unit, the iScout offers a unique capability in one node, does not require burying, and has several battery options including 1.5 Volt AAs, and add-on battery box for extended life through military grade BA 5590 batteries, or a solar panel, as seen in Figure 22.



Figure 22. iScout Image, from [20]

Additional advertised characteristics include:

- Built in global positioning satellite (GPS) receiver.
- 14-day life/external battery for longer life- 3 months, 1 year, & indefinite solar unit.
- Built in tamper.

- Size: 3 ½ x 3 ½ x 1 ¾ inches.
- Wireless RF networked communications.
- Built in seismic, acoustic, magnetic, and PIR sensors-optional switch closure/tripwire.
- Two AA batteries (lithium preferred).
- Solar and extended life power available.
- Weight: 8 ounces.
- Rugged, waterproof case.
- Classification: seismic people, seismic vehicle, acoustic speech.
- Operating Temperature: 40 to + 60°C. [20]

The iScout is lighter and smaller than the TRSS ETU-II or MAGID, as displayed with the size comparison seen in Figure 23.



Figure 23. iScout Size Image, from [20]

Similar to the TRSS ETU-IIs, IRID, and MAGID being able to cue the imagers, the iScout is able to cue the McQ OmniWatch to activate. The iScout target classification includes people and vehicles, but is unable to distinguish between wheeled and tracked vehicles, as TRSS is able to do.

McQ is the leading developer of a ground Radio Frequency (RF) based UGS, or ground radar system, known as the rScene. This UGS is capable of detecting the movement of vehicles and personnel through foliage, in dense urban areas, high traffic areas, marshy areas, and across water. McQ advertises the rScene's characteristics as:

- Very small 5 x 5 x 2 inch RF sensor unit, 4 x 6 $\frac{3}{4}$ x 7 $\frac{1}{2}$ battery case.
- Weight: RF sensor unit 1 lbs., battery case with BA-5390 4.5 lbs.
- Automated target detection and classification; multiple targets can be displayed; tamper alarm if unit is moved.
- Detects and classifies people up to 100 meters and vehicles up to 300 meters.
- Can see through foliage and camouflage.
- Very low false alarm rate; wind, rain, and foliage movement do not cause false alarms.
- Long operational life up to 2 weeks on battery, solar power controller built in.
- RF wireless network communications.
- Meta data includes GPS location; compass pointing angle; target location, speed, and direction. [21]

Not only is the rScene unique in its method of collections, it is rugged, light, and small as seen in Figure 24.



Figure 24. rScene Size Image, from [21]

The digital battle tracking for the rScene shows the type of target within the UGS range fan with the targets direction of movement overlaid on top of digital imagery, as displayed in Figure 25.

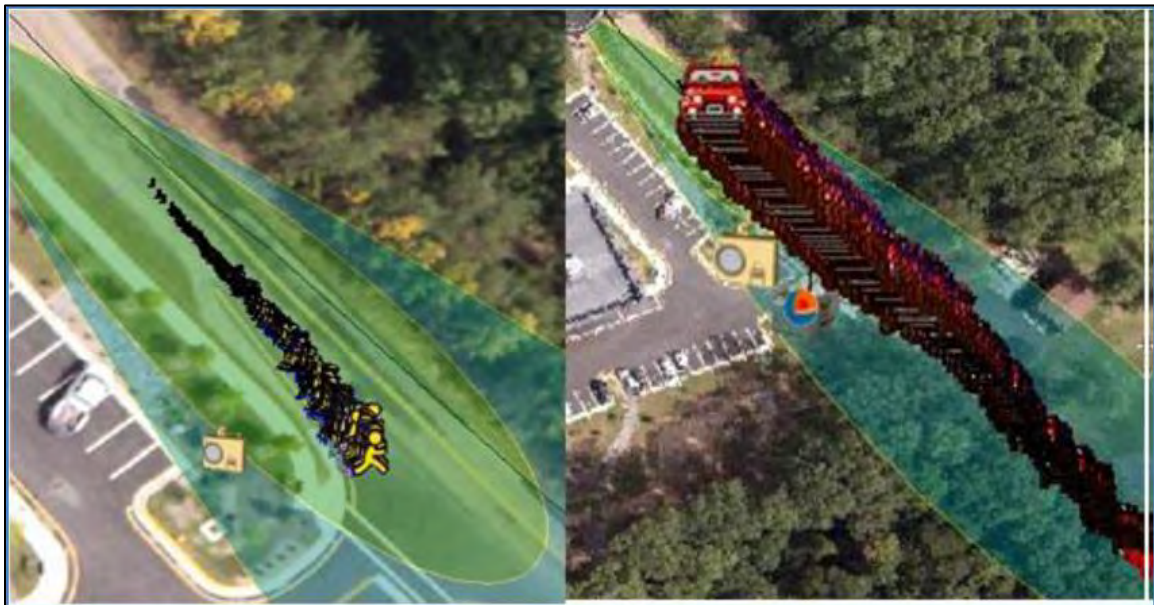


Figure 25. rScene Digital Tracking Projection, from [21]

The OmniWatch is the McQ imaging unit, capable of both color still imagery and FMV, as opposed to the TRSS imagers that just do black and white still imagery. Additionally, McQ advertises the following:

Features: Battery Operated Surveillance; Map Based User Display; Wireless Communications; Video Storage and Replay; Day and Night Cameras; User Interface System Control; 30 Day Persistent Surveillance; User Interface Map Display; 10 lbs. Deployed Kit Weight with Battery; Video on Smart Phones and Tablets; iScout® Seismic, Magnetic, Acoustic, and Passive IR Triggering Sensors; rScene® Triggering Sensor[6].

Upon request, the OmniWatch can be equipped with a TPZ feature that allows for remote offsite independent adjustment of the camera view and angles for better image collections. The OmniWatch imagers are similar in size, shape, and weight to those of the TRSS imagers, yet their connected communications transmitter is smaller and lighter, which is displayed in Figure 26.



Figure 26. OmniWatch Image, from [6]

Although not advertised, the OmniWatch has been proven to detect personnel targets at a range of 3000 m, which is three times that of the maximum range for the TRSS long-range imagers [6].

b. Employment

Employment of the McQ UGS is similar to that of the TRSS, as seen previously in Figure 21. The OmniWatch must communicate with other UGS and repeaters, the repeaters must communicate with others to relay their signals, and these signals are relayed to a base station for digital monitoring.

There are several key employment factors unique to the McQ UGS that allow for increased flexibility in mission support. All the McQ UGS and associated components, to include solar panels, can be covered up for concealment. They also come equipped with fake rocks and branches (other parts of natural or manmade terrain available upon request) for concealment. All McQ UGS are capable of utilizing solar power technology, which can extend the life of an UGS past 90 days in the field. McQ offers an AD capability for the iScout UGS, dropped out of fixed or rotary wing aircraft for employment. The use of RF UGS in the rScene is a unique detection method for intelligence collections offers a significant employment capability in dense terrain or amphibious environments. McQ uses their proprietary Terrestrial Network (TNet) for UGS communications, which is an autonomous, low power, RF-based, mesh network capable of overcoming terrain obstacles or obstructions [22]. Additional characteristics of the TNet include:

- Sensor information relay easily set up in the field.
- Self-forming and self-healing mesh ad hoc network.
- Automatic recognition and reporting of neighbor sensors or repeater units.
- Guaranteed delivery of messages.
- Very low power consumption with solar recharging options.
- Long RF link distances with multiple repeater architecture.
- Very fast delivery of target alarms and images.

- Internet protocol network connectivity.
- Outdoor rugged environment and rack mount units. [22]

The TNet allows for various communications methods and ranges capable of fusion for optimal employment and range in using the McQ UGS. It is encryption capable and has an internal solar power charger for the repeaters to aid in extended battery life. Also related to communications is the cellular communications capability offered by the vWatch for McQ [23]. This system allows for the establishment of an independent cellular communications structure to be established for long-range communications. This communications system is new, encrypted, based on state of the art cell phone technology, and highly reliable. For networking, McQ uses the Open Standards for Unattended Sensors Data Protocol for broadband and narrowband communications, allowing for a streamlined interface between the field devices, central servers, and user interfaces all through Internet protocol networks [23]. This allows for standard viewing of UGS collections data sets on multiple approved systems.

c. Summary

McQ UGS are very similar in type and employment to that of the TRSS. Although they are used for many other missions than those that would be supporting intelligence collections, given the operational demands of *EF 21*, McQ UGS could greatly augment the already existing TRSS capability. For employment, having a RF UGS such as the rScene is a welcomed addition and new capability. The FMV capability and range of the OmniWatch would bolster the existing TRSS imagers. A communications network system such as the TNet aids in command and control of the UGS to a degree unmatched by TRSS. In addition, the AD, remote base station independent configuring, use of an Android smartphone for onsite monitoring and configuration, and digital COP system interface are desired capabilities for the TRSS.

3. DARPA ADAPT Overview

These UGS possess several unique capabilities found in their single encased node that contains multiple sensors for standardized employment. The UGS v2, the final node

prototype developed under the ADAPT program, contains three passive IR sensors, two cameras (EO or IR capable) for images or FMV, a magnetic sensor, and a seismic acoustic sensor. Additionally, ADAPT has an RF or radar sensor to be emplaced in the node as needed. ADAPT is capable of communicating through the UHF and VHF spectrums, as well as through WiFi. The nodes are self-contained, as shown in Figure 27.

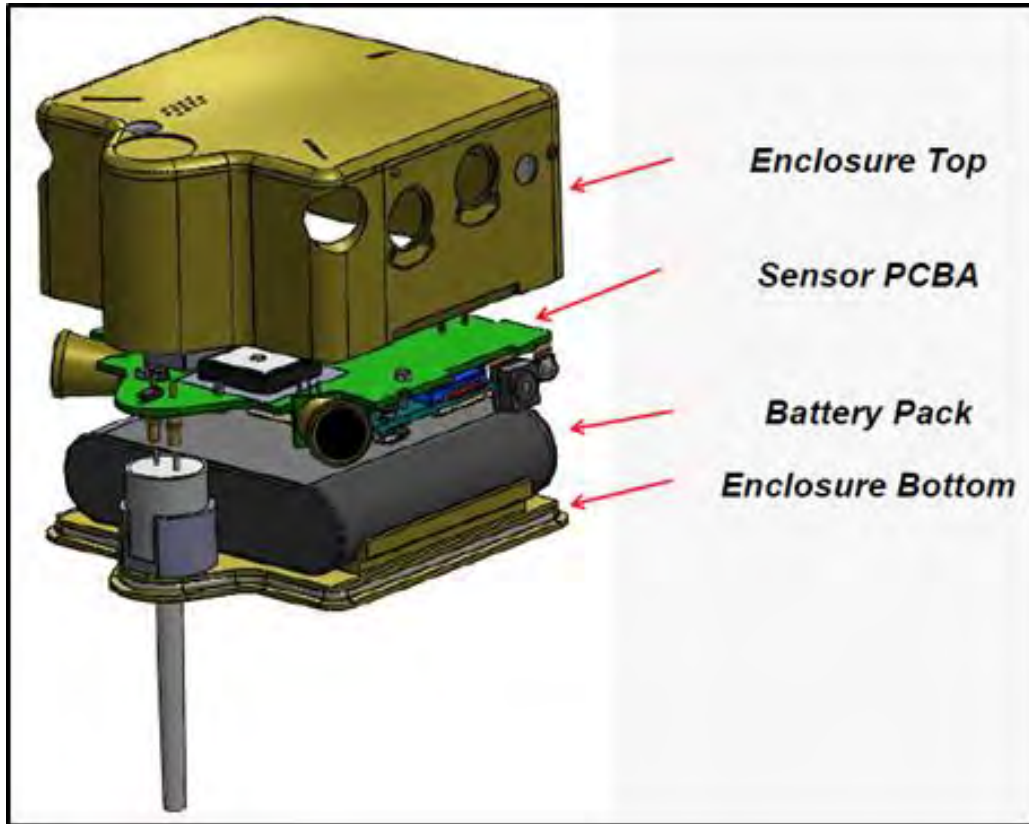


Figure 27. ADAPT Node Configuration, from [24]

This system is designed to create a meshed network interconnecting the nodes autonomously, while also establishing a reach-back link to communicate with the monitoring station. The objective of this programs states,

The Department of Defense (DOD) recognizes that a significant break from current practice is required to rapidly develop low-cost intelligence, surveillance, and reconnaissance (ISR) sensor systems. The ADAPT program seeks to deliver this breakthrough by adapting manufacturing approaches traditionally employed in commercial technology and by developing/ implementing novel development techniques/processes. [25]

This objective outlines the ADAPT's innovation and potential, which drives UGS advancements in a new productive direction. Additional characteristics include:

- Smaller, more compact design (3.2x3.6x1.6-in; 345 g).
- Integrated ridge (analogous to a gun sight) that allows precise alignment of passive infrared (PIR) sensors and cameras.
- Extensible skinning concept to supply an irregular profile and facilitate camouflage.
- Quick response code label on bottom of case that provides software unit identification and android debug bridge serial number.
- Three narrow-beam PIR sensors spaced equally around outside (i.e., 120°), tilted slightly up to aim at ranges between 1–20 range, and capable of reporting movement as left-to right or right-to-left (v. just on/off).
- Two standard flash cameras.
- Audio input channel.
- Screw thread on bottom of case allowing an optional spike to improve seismic sensing.
- Vertical single-axis geophone connected mechanically to optional spike.
- Tripwire capable is using an externally accessible switch sensor to which a tripwire can be attached using a magnet.
- Two externally accessible terminals for software-controlled switched output power.
- Report of unit orientation.
- Externally accessible standard micro-universal serial bus connector that provides a data interface to the ADAPT core.
- Rechargeable 10.4 Ah battery that is field swappable without special tools
- Weather and water resistance.
- Speaker that can broadcast audible alarms for deployment and/or testing (e.g., unit booting).
- Simple, externally accessible on/off switch. [25]

The ADAPT was first designed as non-lethal mines in addition to surveillance assets, and has since then evolved to meet the original requirements as well as hosting new capabilities.

a. Equipment Specifications

Unique to ADAPT along with the single encased node, is the Passive IR (PIR) synchronization capability, as shown in Figure 28.

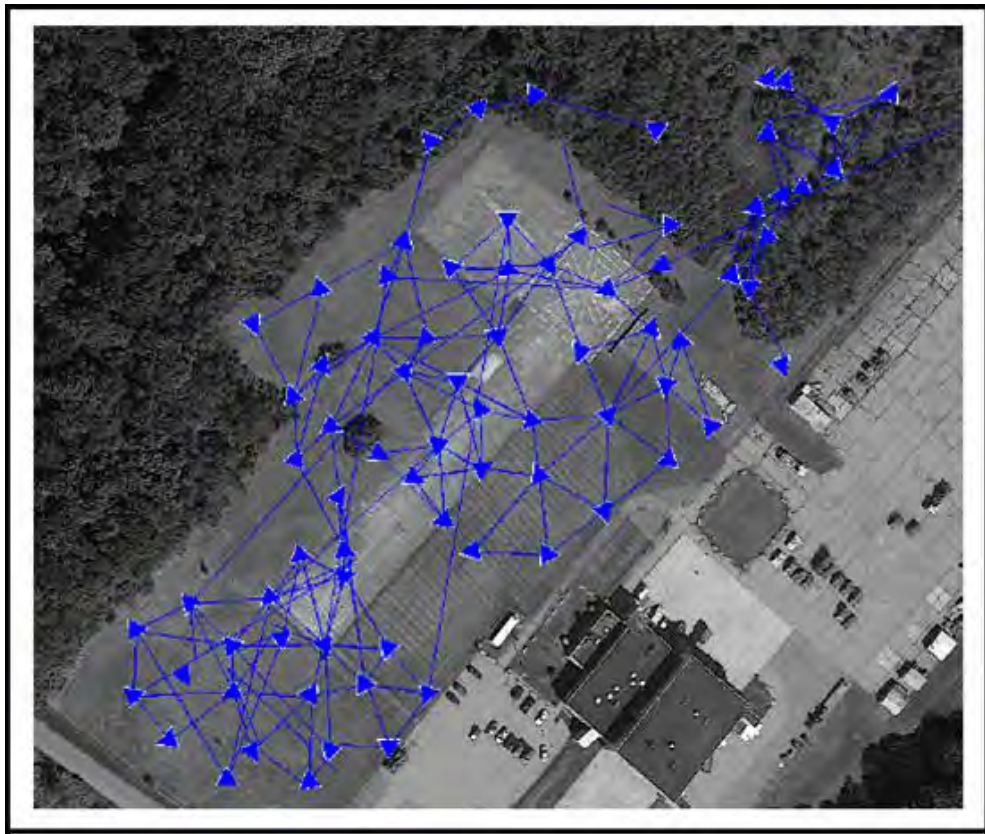


Figure 28. ADAPT Network Connectivity Image, after [25]

This capability allows the UGS to become linked to each other in a Wireless Sensor Network (WSN), which requires the PIR sensors to be on and form an invisible tripwire system with other nodes. Once a tripwire is broken, it will then cue the cameras to activate, as well as wake up the nodes nearest to the activating ones so they become

alert for collections. Additionally, when the WSN is established the other sensors can be programmed to go to sleep, thus preserving the battery life of the nodes.

Other features common to all the ADAPT nodes is a rechargeable lithium battery, an offsite remote configuration capability, multi-sensor cuing for the cameras, digital COP systems interface, signal relay ability with repeaters, and an AD capability. The circuitry in the ADAPT nodes is based on modern day cell phone technology, which allows for a variety of channels and components to be used, as seen in Figure 29, as well as the previously discussed sensor types and dimensions.

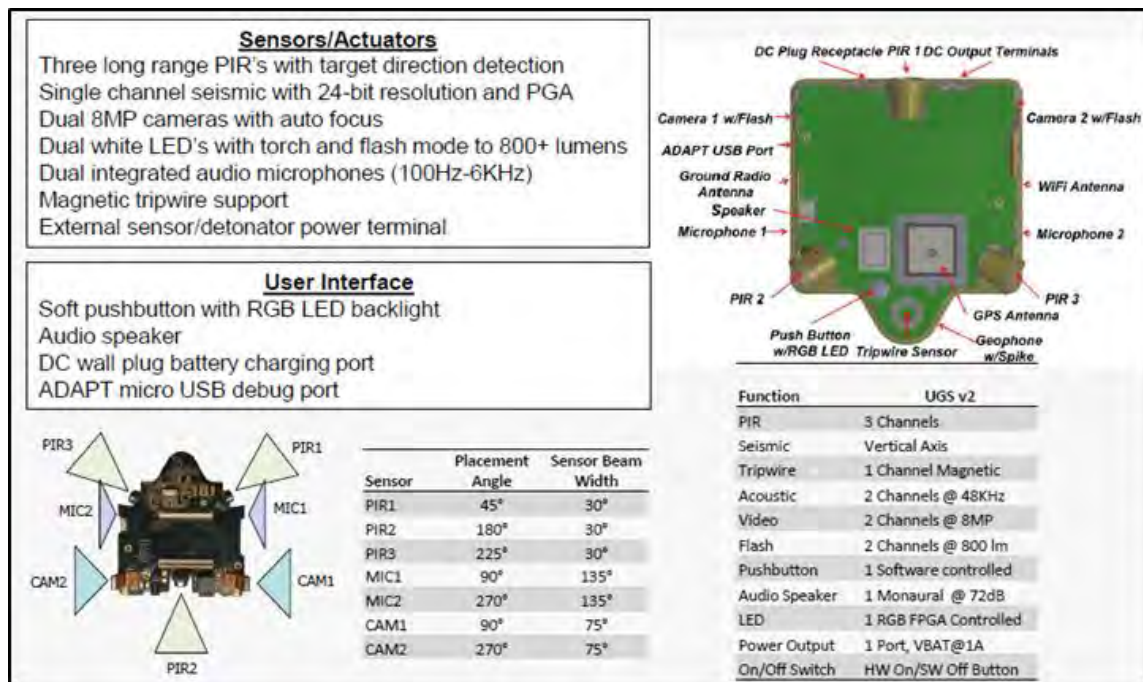


Figure 29. ADAPT Capabilities Diagram, from [24]

The WiFi communication network is newly advanced and once established, very reliable. However, WiFi is very susceptible to Electronic Warfare (EW) jamming; should this method of communication be employed, it would best occur when the enemy has a weak signals intelligence or EW capability. Unlike TRSS or McQ's OmniWatch, ADAPT has neither long-range imager capability nor an onsite portable configuration device like the TRSS HHPM.

b. Employment

ADAPT UGS offer a unique employment capability based on standardized form-factor encased nodes and the WSN link for joint sensor detections. These UGS can be emplaced much faster than the TRSS UGS, and in a similar fashion to the McQ iScout, just turn them on and drop them. Without the seismic spike, the ADAPT nodes can be air delivered. They are designed for employment as a family or with several UGS at the same time linked to each other, similar to TRSS with sensor strings of 3–5 UGSs, creating redundancy for increased chances of success. In addition, the sensors have specific ranges and angles of detection as show in Figure 30.

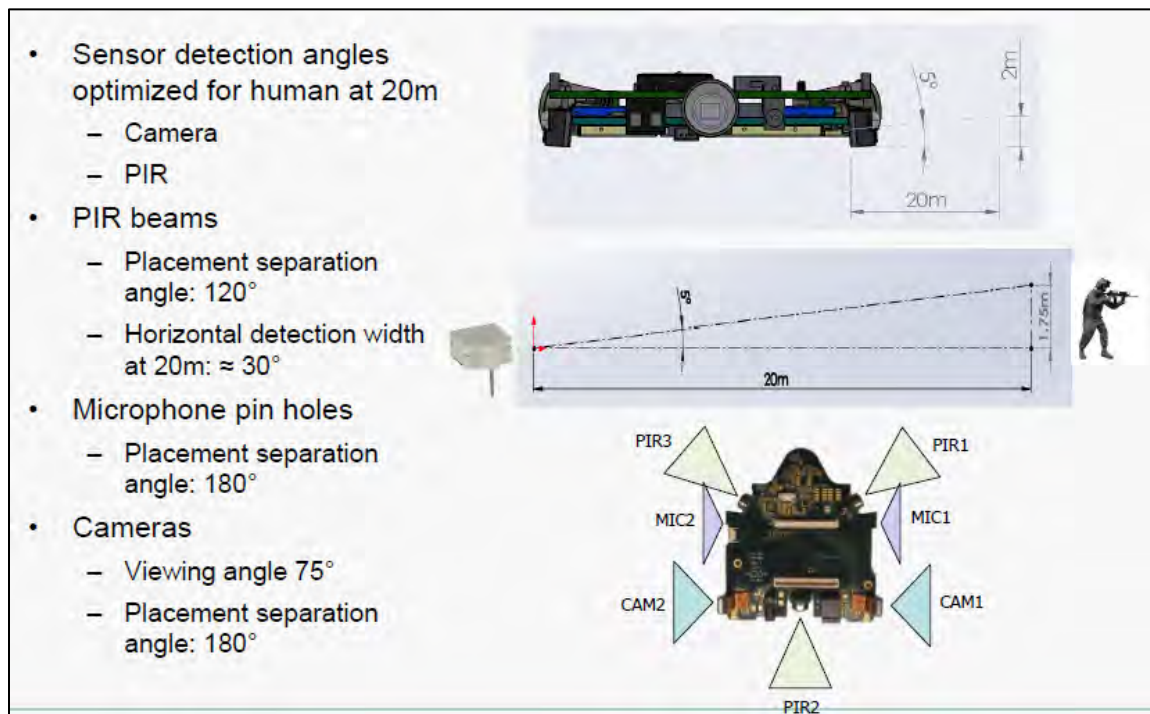


Figure 30. ADAPT Ranges, from [24]

For concealment purposes, the ADAPT UGS can be buried, covered with foliage, fitted for fake rocks, painted, or sprayed with adhesive allowing the terrain to stick to the node, as long as the PIR and camera sensors are exposed. The activation display, similar to the picture in Figure 30, will display the UGS GPS location, camera pictures, and the node's battery life.

c. Summary

The ADAPT offers a different yet dynamic approach to sensor employment with modern cell phone technology. Due to the small size of the nodes, the sensors have limited detection ranges, however their reliability and battery life match those of the other UGS. Creating a standard case with unique nodes able to be configured based on the mission parameters, along with a rechargeable battery, greatly aid in overall flexibility for employment. The speed of employment, WSN capability, size and weight of the nodes and use of current cell phone technology make this system an amazing intelligence collections asset with the potential to upgrade the USMC's existing UGS capability. However, as the status is that of prototype artifacts, a full-fledged production program would need to be initiated to bring the capability to the fleet.

D. UGS EQUIPMENT ANALYSIS

The primary advantage of TRSS is that it has maintained a lasting relationship with USMC, which shows reliability and trust. TRSS has proven to work for Marines in combat operations and amphibious operations, all existing through various harsh environments over several decades. It has always been capable of establishing near real time NRT reporting and, unlike ADAPT, it has both short and long-range imagers. However, several disadvantages exist with TRSS, one being that it is bulky and heavy as compared to ADAPT or McQ. Further, TRSS has no alternate power source such as solar or rechargeable batteries. TRSS imagers have a limited range when compared to those of McQ. They also lack FMV, TPZ, and color imaging capabilities. There is no digital COP interface, no remote autonomous configuration from the SMG, and instead of an android smartphone for onsite configuration, it has the bulky HHPM, which lacks a touch screen capability. TRSS lacks radar UGS, AD capability, and any alternate form of communications beyond VHF, UHF, and SATCOM. The ETU-II requires burying for proper functioning, which adds employment considerations for time on the objective and concealment. TRSS has no GPS integration and it has no casing ability, so each of the different sensors is separate.

McQ offers state of the art technology, flexibility, and a well-established reputation with customers such as Department of Justice, SOF, and other DOD units. Their imagers are TPZ, FMV, and color capable. Using the proprietary TNet for data communications, McQ has faster data transfer rates than TRSS and incorporates advance data encryption software. It supports a digital COP interface, includes a cellular communications option, and an interface for an android smartphone for onsite programing. McQ has an AD capability and extended battery options, to include solar panels. Finally, it supports radar UGS in the rScene form factor,

ADAPT is small, light, and easy to employ, while remaining flexible with a radar UGS, WSN for node-to-node communication, and WiFi for an alternate means of communications [12]. These UGS use current relevant cell phone technology in a unique yet simple concept. ADAPT requires no onsite programming and has a digital COP interface capability. Constraints include limited UGS detections ranges, no long-range imagers, limited testing, and lack of existing robust production capability.

Table 8 is derived from a detailed analysis of the different UGS systems' capabilities and several other factors that aid in flexibility for UGS employment missions supporting *EF 21* intelligence collections.

Table 8. UGS Equipment Comparisons, after [6], [12], [18]-[25]

UGS Equipment Comparison Table				
		TRSS	McQ	ADAPT
Sensor Ranges	Seismic with Acoustic	10-50m	10-50m	20m
	IR	20-50m	10-50m	20m
	Magnetic	4-25m	10m	10m
	Short Range EO/IR Imager	150-500m	200-500m	20m
	Long Range EO/IR Imager	450-1000m	1000-2000m	N/A
	Radar	N/A	100-300m	10m
Sensor Weights (lbs.)	Seismic with Acoustic	3	Integrated	Integrated
	IR	0.8	Integrated	Integrated
	Magnetic	1	Integrated	Integrated
	Short Range EO/IR Imager	10	10	Integrated
	Long Range EO/IR Imager	12	10	N/A
	Radar	N/A	1	Integrated
	Overall Node	N/A	iScout = 0.7	0.8
Communications	VHF	Yes	Yes	No
	UHF	Yes	Yes	Yes
	Satcom	Yes	Yes	Yes
	Other	N/A	Cellular	WiFi
	Relay / Repeater Capable	Yes	Yes	Yes
Additional Characteristics	Burying Required	Yes	No	No
	Tripwire Attachment	No	Yes	Yes
	Imagers TPZ Capable	No	Yes	No
	Imagers FMV Capable	No	Yes	Yes
	Digital COP Interface	No	Yes	Yes
	Casing Ability	No	Yes, iScout	Yes
	Battery Life	30-60 days	14-90 days	14 days
	Battery Type	9 Volt or BA5590s	AA or BA5590s	Lilon Battery Pack
	Extended Battery Life Option	90-180 days	90-180 days	N/A
	Additional Battery Options	N/A	Solar	Rechargeable
	Air Delivery	No	Yes	Yes
	Remote Autonomous Configuration from SMG	No	Yes	Yes
	Near Real Time Reporting	Yes	Yes	Yes
	GPS Tracking	No	Yes	Yes

This table reflects a summation of four major areas for analysis when factoring in the UGS ability to support intelligence collections missions in non-permissive environments under conditions of distress, such as those described in *EF 21*. Although TRSS and McQ are very similar in sensor range comparison, McQ pulls ahead with their long-range imagers and radar UGS. Sensor weight is usually a moot point based on quantity of UGS and batteries carried; however, lighter is always better, and in this comparison ADAPT wins. For the communications comparison, McQ offers a unique capability in cellular as does ADAPT with WiFi, both aid in mission flexibility and enhance the UGS ability for employment. The other unique factors compared on this table offer great insight as to the UGS flexibility, leaving McQ as the better choice based on systems integration, communications capability, and imager capability. It is the only UGS system to offer imagers to view targets at a range greater than 1000 meters, plus a tilt-pan-zoom capability and full motion video. ADAPT and McQ have several similarities in the digital COP interface, autonomous configuration, AD, radar UGS, GPS integration, no burying requirement, FMV imagers, and an alternate means of communications. All these areas are fields that these two systems currently possess, where the TRSS vendor is continuing to research, design, or implement such capabilities leaving it at a severe disadvantage [26].

E. CONCLUSION

The analysis of the units and technologies associated with UGS in the USMC fosters great optimism for adjustments and advancements in a field that yearns for and rates upgrades not only to support intelligence collections operations for *EF 21*, but also to better support the Marines as a whole. The reconnaissance battalions and intelligence battalions are both successful establishments with talented Marines, the unit base research shows that when it comes to the employment of UGS the Surveillance Sensor Operators have the technical skill but lack the field craft and endurance of the reconnaissance specialists. TRSS has a long established role with the USMC, however McQ UGS and ADAPT are advanced in areas that TRSS cannot match and by the time it does, it will likely continue to be behind due to current technological advancement rates. Modification of the GSPs tables of organization and tables of equipment as well as the TRSS program

of record must be done to advance the role of UGS in the USMC and to increase the potential of the USMC organic intelligence collections assets as a whole. Based on the analysis in this chapter, in addition to the literature analysis of Chapter II, Chapter IV provides fusion of this information using a systems engineering approach to revitalize UGS in the USMC.

IV. SYSTEMS ENGINEERING ANALYSIS

The purpose of this chapter is to apply the information collected from analysis of the respective literature in Chapter II and research in Chapter III to the systems engineering (SE) process for the development of new solutions. The perspective of this chapter is that of a program manager tasked with evaluating and improving the use of UGS in the USMC to support *EF 21*. The use of SE concepts and designs gives structure to evaluating and assessing the system and all the associated components. Using this process aids in determining new and innovative ways to employ, train with, and test UGS.

The main reference used for this process is *Systems Engineering Management* by Benjamin S. Blanchard. The method utilized is to apply a select and modified SE approach, mainly the SE major elements and design requirements, to a standard format for the Doctrine, Organization, Training, Materials, Leadership, Personnel, Facilities (DOTMLPF) construct [27]. Not all portions required the same amount of research or modifying, some contain overlapping issues, but all rate addressing to add structure and validity to the overall process. Using this process for revamping UGS in the USMC for *EF 21*, plus the proposal of a new table of organization (Figure 34), some conceptual overlaps in the areas of organization, training, leadership and personnel now exist. The result of this chapter is recommendations for improvements in UGS as a system for the USMC to support the new increased demands brought about in *EF 21*.

A. SYSTEMS ENGINEERING DESIGN

To properly format a plan for UGS in the SE design construct the definition of a SE process must become clear. A system, defined by military standards is

a composite of equipment, skills, and techniques capable of performing and/or supporting an operational role. A complete system includes all equipment, related facilities, material, software, services, and personnel required for its operation and support to the degree that it can be considered a self-sufficient unit in its intended environment. [27]

Relative to UGS for the USMC, the DOTMLPF format will provide sufficient context for evaluation of the system, based on this definition. Figure 31 is from Blanchard's *System Engineering Management 4th ed. 2008*, from which it gives graphic detail to the previously stated definition.

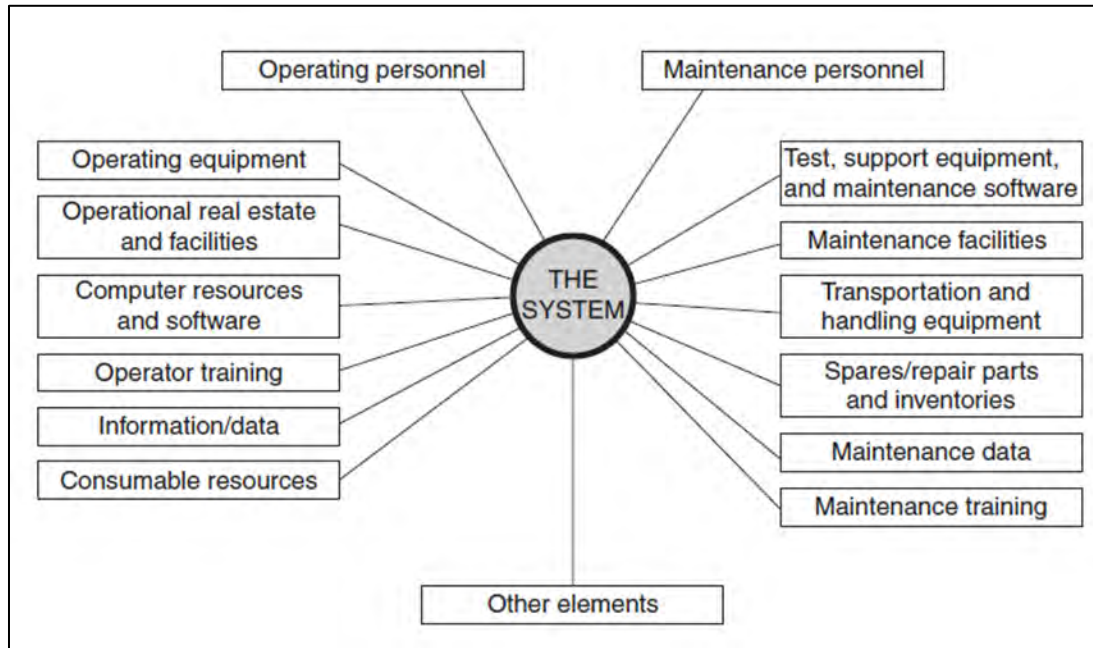


Figure 31. Major Elements of a System, from [27]

Analysis of these major elements of a system applied to UGS for the USMC poses a credible set of topics for evaluation and possible future development. In the evaluation of a system, understanding the system design elements, the current environment for the design, and the design requirements are the key focus areas for a detailed evaluation. Figure 32 is from Blanchard's *System Engineering Management 4th ed. 2008*, and it shows the very detailed layout of the system design requirements for the SE process.

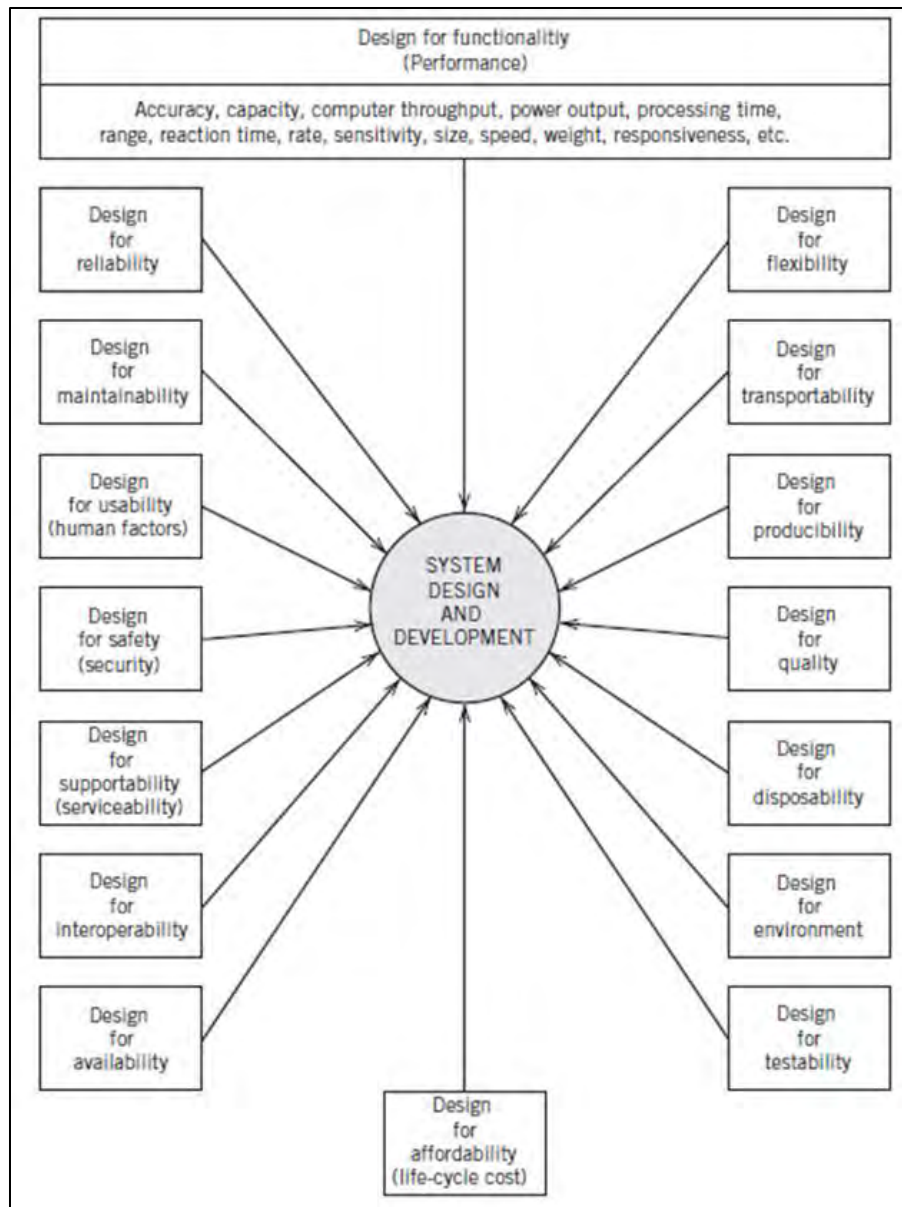


Figure 32. System Design Requirements, from [27]

Not all the elements from Figure 32 are researchable in each section of the DOTMLPF for UGS in the USMC; however, all are crucial to certain aspects of the SE process in their own right.

B. DOCTRINE

As discussed in Chapter II, this is an area in much need of refinement relative to the role of UGS in the USMC and the employing unit. With the *Remote Ground Sensors*

publication being dated and inaccurate, the *MAGTF Intelligence Collection* publication containing conflicting information, and the *Ground Reconnaissance* publication still in draft form yet leading the path for the previous two to be refined, UGS doctrine must become clarified and modernized to support *EF 21* intelligence collections missions. Following the SE approach, the key system elements relative to improvements in UGS doctrine are the operating equipment, and operational concept elements [27]. The most important SE design requirements for UGS doctrine are those pertinent to reliability and supportability [27].

The *Remote Ground Sensors* publication discusses several key elements; however, it needs updates, which fosters little confidence in a reader that is inexperienced with UGS and trying to learn. The technical UGS aspects need removing from the doctrine and should remain solely in the technical manuals, allowing the doctrine to stay consistent even as technology changes. This may be a controversial concept, but over the years as UGS have improved, they have become smaller, lighter, gained longer lasting batteries, and imagers. However, the majority of the sensor types have stayed the same, with consistent ranges such as the magnetic and IR. If the technical details are in the doctrinal publications then the doctrine will never be current, which is why the concepts need to be in the doctrine and the specifications in the TMs. The information/data relative to the users of UGS and the reporting of UGS needs to be refined for commonality at all levels for the MAGTF. The operational concept elements are those in the doctrine that directly affect the warfighter, such as roles and responsibilities, ownership of equipment, reporting requirements, planning cycles such as Figure 4 and Figure 8, and employment techniques. All three of the UGS-related publications touch on these areas; again, upgrades are required based on recent combat deployment after action reports and commonality between the publications in these areas.

Creating new UGS doctrine or updating existing doctrine necessitates referencing of sound tactics and current structure, which demands reliability. Historic after action reports from combat operations will provide great rationale to drive modifications of UGS doctrine, which will add great clarity to the missions and environments UGS can support. The doctrine must be supportable, which means the *Remote Ground Sensors*,

MAGTF Intelligence Collection, and *Ground Reconnaissance* publications will need modifications in the same areas, mainly roles and responsibilities, command and control, units, and the employment of UGS.

C. ORGANIZATIONS

Currently all of the USMC's UGS fall under the ownership of the GSPs, which are subordinate to the BSCs of the intelligence battalions. However, as explained in Chapter III, the reconnaissance battalions also have tasks to employ UGS, creating redundancy in the two units. The GSP's design is to support all MEF operations, to include task-organized forces, to serve in direct or general support of the MAGTFs or other elements as needed. The intelligence battalions are capable of conducting first and second echelon maintenance on all UGS at their locations; for third echelon maintenance, the UGS receive processing through the unit supply system back through MARCORSYSCOM for specific vendor support. If roles and responsibilities are to change for the ownership and maintenance of UGS then this methodology will require modifications as well. Using the SE process for analysis, the key system elements for organizations using UGS in the USMC are the operating and maintenance personnel [27]. The most essential SE design requirements relative to the GSP organization are the design for flexibility, design for availability, and the design for the environment [27].

Figure 33 shows the current 1st GSP table of organization.

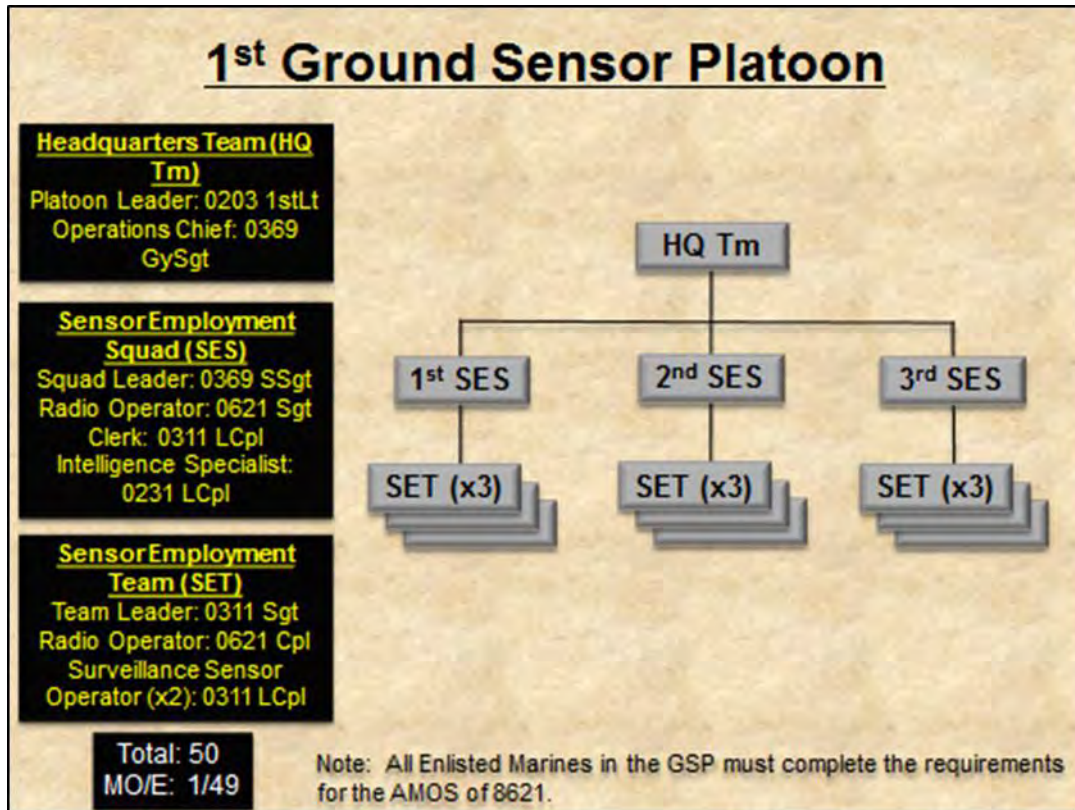


Figure 33. Current 1st GSP Table of Organization, after [14]

The intelligence battalions own all the operating personnel based on its technical and tactical proficiencies as well as its ability to support the MEF. However, the GSPs still lack the ability to support *EF 21*-like missions with a SPIE capability and advanced ground reconnaissance skills. Figure 34 depicts the author's proposed GSP table of organization, enhanced to support *EF 21*.

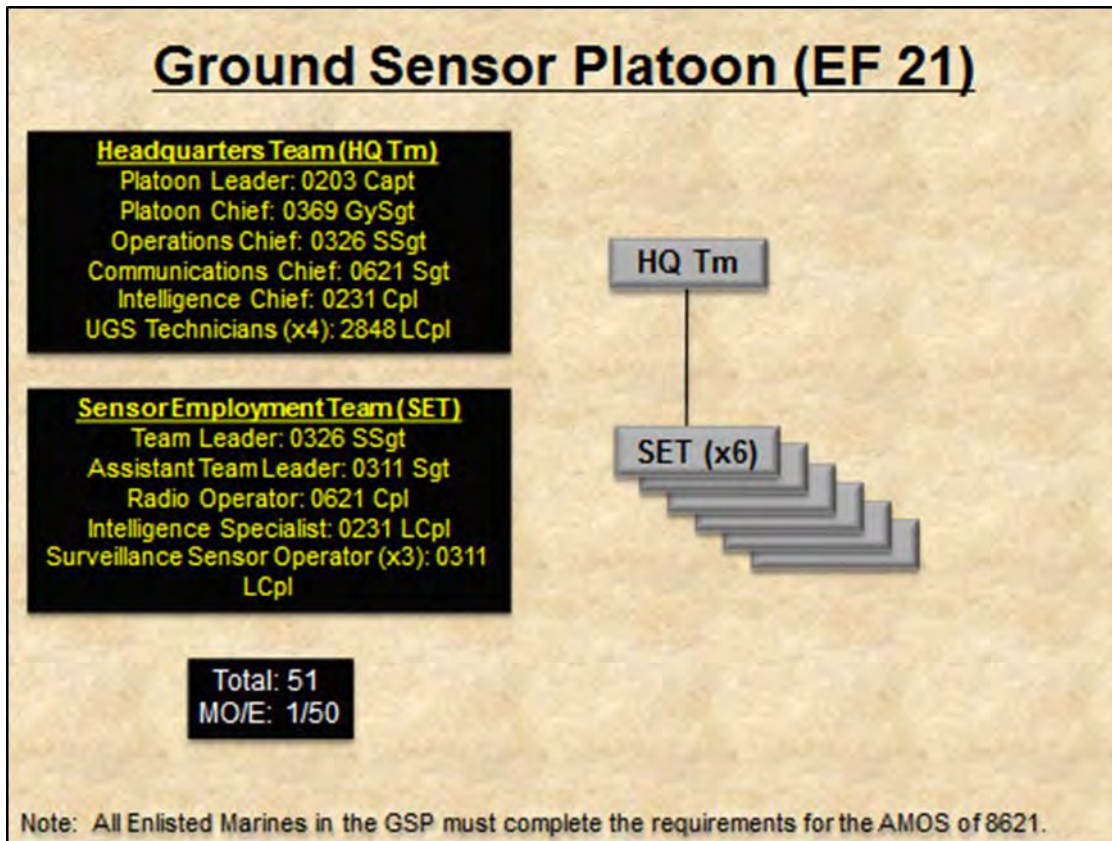


Figure 34. GSP (EF 21) Table of Organization, after [14]

The SESs and three of the SETs are deleted from the existing structure and their personnel are absorbed into the remaining six SETs, which are bolstered with more personnel and Reconnaissance Man (Parachute and Combat Diver Qualified) MOS 0326 Staff Sergeants (SSgts) as Team Leaders. Currently, few existing missions require an SES for support. This new structure allows the SET to be the lowest level maneuver element, with a larger and more diverse HQ Team to handle the traditional roles such as command and control and logistics, as well as support new functions such as to provide liaison elements and intelligence support for advanced UGS operations in non-permissive environments, as discussed in *EF 21*. Although the TRSS Technicians are organic to the system support platoons for the intelligence battalions, the GSP (*EF 21*) model allows four UGS Technicians to be at the GSP, based on new technologies to support those units. This change exists to support the unit as needed onsite and to be able to fix more issues at the lowest level before reaching out to the battalion for maintenance support.

Flexibility is a Marine tenant, part of USMC history and long standing ethos, which in turn serves as a pillar to intelligence collections for *EF 21*. UGS aid in providing commanders flexibility in intelligence collections and maneuver, which when merged with ground reconnaissance units can significantly expand their capabilities. Currently, the GSPs are task-organized to support MAGTFs of all sizes, anytime, and in any place, which reinforces the concept of flexibility. An organization of this kind must be available for tasking to support the demands of the USMC and to perform no matter what or where the mission.

The GSPs are capable of completing most of these available tasks, however as *EF 21* grows and becomes second nature, necessary modifications to the organizational construct now present themselves. The GSP (*EF 21*) table of organization allows the SETs to be more flexible and capable of supporting maneuver and intelligence collections missions, based on their increased size and new MOS structure.

Combat operations over the past ten years have placed Marines in some extremely difficult environments against tough, complex foes. Units must be capable of working in all environments, especially with UGS. In addition, if the demand signal increases for the employment of UGS in non-permissive environments for the USMC general purpose forces, this new table of organization places Marines at the GSP with SPIE skills, as well as advanced ground reconnaissance and field craft skills, now able to train the rest of the platoon for UGS missions in non-permissive environments. The new reconnaissance SSgt Team Leader would be capable of attaching to a reconnaissance team to conduct SPIE for the employment of UGS in support of intelligence collections operations for *EF 21*. To recap key concepts from Chapter III, a doctrinal reconnaissance element's primary tasks are to gain access to the battlefield, support maneuver operations as a maneuver element or through intelligence collections, and provide vital information to targeting efforts [3]. SET Leaders with ground reconnaissance experience as well as now an added UGS employment capability, fused with the reconnaissance team will greatly increase their chances for success, reduce overall risk, and provide longer advance ground surveillance in support of *EF 21* missions unlike anything the MAGTFs have done before.

D. TRAINING

With the new GSP (*EF 21*) table of organization, additional training and readiness events are required for the Surveillance Sensor Operators to support advance ground reconnaissance events and SPIE, referencing the reconnaissance MOS training and readiness manual for compatibility and structuring. The SPIE training events will be for the reconnaissance SSgts in the GSP, for they would come to the GSPs already capable in all the USMC aspects of SPIE, just requiring sustainment training. This would allow the GSPs more training time at their base stations and not require additional schools for the other Surveillance Sensor Operators, which would be time away from home and mission specific training. The result would be a reconnaissance SSgt able to detach from the SET and attach to a reconnaissance team to support them with UGS, as in Chapter I, Figure 3. In addition, the SET as a whole is now more capable with the implementation of the GSP (*EF 21*) table of organization, with this comes the increased requirement for advanced training for more complex missions possibly require SPIE techniques. The key system elements related to training for UGS in the USMC are the transportation and handling of equipment and operator training [27]. The most important SE design requirements for training to *EF 21* standards relative to the employment of UGS for the USMC are in the design for quality and testability [27].

The transportation and handling of equipment for UGS in the USMC is a key issue relative to training because the movement and employment of UGS is in direct relation to the size, shape, weight, and durability of the UGS. The smaller the UGS the greater the ease in transporting, as well as the greater the quantities that can be carried by an individual Marine, which effects overall mobility and the training standards associated with it. This is essential for *EF 21* missions that require SPIE methods or dismounted movements through rough terrain because increased weight could result in increased risk. Inadequate training could lead to improper employment; improper employment of an UGS string can be the difference between a successful mission over months and a compromised mission in a matter of hours.

Currently, the Surveillance Sensor Operators receive training from formal schools, MEU work ups and deployments, and real world missions, as well as platoon-

level training supervised by the intelligence battalions. All of these training opportunities focus on conducting operations in a semi-permissive environment or possibly in a non-permissive environment with additional support for security. With the tasks modified to support *EF 21*, enhanced technology sensors training fused with reconnaissance expertise foster a relationship for the creation of advanced training plans in the areas of ground reconnaissance and SPIE. The addition of reconnaissance SSgts as the Team Leader and Operations Chief as per the GSP (*EF 21*) table of organization, will greatly aid in advancing the GSPs overall level of field craft, ground reconnaissance, reporting, and planning skills for operations with limited support in non-permissive environments.

Coordination of SPIE training for the GSPs would require a memorandum of agreement between the intelligence battalions and reconnaissance battalions. This would allow the SET to receive partnered training with the reconnaissance battalions, since the reconnaissance battalions have the majority of the required MEF-level support equipment and personnel for SPIE operations. The majority of the training agreement would be so the reconnaissance SSgts in the GSPs could stay current on their airborne and dive capabilities. These modifications to the current USMC training would support the new organic capability, highly versatile, prepared, and able to access the battlefield at any point and emplace UGS to provide increased flexibility through technical ground surveillance.

Currently, the highest degree of training and evaluation a MEU can receive is that coordinated and evaluated by the Expeditionary Operations Training Group (EOTG). This is an area that requires slight changes, mainly for additional tests to support *EF 21*-based training requirements and a mirror image of what they do to support evaluations with MAGTF work-ups. EOTG-led training is where SETs receive their greatest testing and evaluation in their ability to collect vital intelligence for amphibious assault and raid operations. With the GSP (*EF 21*) table of organization, the evaluation would require modification to assess the SETs increased ground reconnaissance capability, SPIE ability of the SET, and the Team Leader in an attached role to a reconnaissance team for the employment of UGS.

Other evaluation areas where training would need modification based on the GSPs new design would be for the employment of UGS in the Integrated Training Exercise at the MAGTF Training Center at Camp Twenty-nine Palms, California. This exercise consists of a six-week desert training package for infantry battalions, focused on offensive, defensive, and counter insurgency operations. The evaluators are hand selected officers and SNCOs, each a subject matter expert in specific aspects of maneuver warfare. The increased use of the GSPs for this training will not only promote advertisement and service education for their new capabilities, but also test them in very rigorous and demanding environments.

E. MATERIALS

UGS require several components and systems for proper functioning because a single mission could require a diverse multitude of batteries, cables and connectors, radios and relay devices, monitoring equipment, and computers. The technology associated with UGS is constantly evolving, as seen with the ADAPT use of cell phone technology in Chapter III. This rapid technological growth requires a streamlined plan to keep the use of UGS innovative and adaptive to the warfighters' needs. Using a SE approach, TRSS needs a detailed analysis of its current operating and maintenance equipment, as well as its requirements for flexibility and maintainability. Relative to the existing materials for UGS in the USMC, there is significant room for growth to meet the goal of *EF 21* intelligence collections missions. The most important system elements pertaining to UGS in the USMC fall under the categories of operating and maintenance equipment [27]. Significant SE design requirements affecting the materials for UGS in the USMC occur in the design for flexibility [27].

The operating equipment includes the UGS, the associated employment and monitoring components, as well as the communications equipment (radios and computers). Commercial companies, as discussed in Chapter III, can produce new equipment and capabilities such as ground radars and long-range imagers in a much more expedient rate than the USMC with TRSS. The USMC needs to increase its level of collaboration with the commercial sector so it can receive new and current UGS in a

method that supports placing the most relevant technology and most advanced capability in the warfighters' hands in the most rapid manner. Dissolving TRSS and collaborating with a commercial company or companies such as McQ, similar to the other services including SOF, would address this concern. The existing capabilities of McQ, as shown in Chapter III, provide for a much more flexible, and advanced capability to support the needs of *EF 21* and enhance the current service level of intelligence collections.

The maintenance equipment is well organized and well structured, but if the USMC acquires more or different UGS from a commercial company, Marines will become more reliant on these companies for maintenance support. This is a welcome and needed relationship because the commercial sector can track and upgrade the equipment at a much faster pace than the DOD. In the short term (three to five years), the commercial sector can process and field technological state-of-the-art equipment as soon as it is test approved; long-term commitments such as those longer than ten years, however, may pose an issue for some of the contracted items. Regardless, planning for UGS technologies ten years from the date may be a fool's errand, since technology is advancing at a substantial rate.

To maintain flexibility, UGS have to be reliable, tested, rugged, user-friendly, and capable of performing at any time and in any place. The warfighter requires systems that are capable of operating in extreme environments under harsh temperatures, and through rough. Additionally, different types of UGS with a variety of communications options need fielding to maintain flexibility in mission support. Currently, as seen in Chapter III, TRSS has fewer types of sensors and few modes of communications than the other UGS discussed, leaving them less flexible to match UGS to the terrain and enemy for employment or to configure data transfers for optimal and timely long-range communications. USMC partnerships with commercial companies would greatly aid in the acquisition of an existing commercial application for a service capability upgrade.

F. LEADERSHIP

The current GSP structure calls for one officer and four Staff Non Commissioned Officers (SNCOs). The GSP commanders are Ground Intelligence Officers, MOS 0203,

with a rank of First Lieutenant (1stLt). They receive three weeks of ground reconnaissance planning and two weeks of intelligence collections training at the Ground Intelligence Officers Course in addition to continual use of these skills throughout the last eight weeks of the twelve-week course. Additionally, the Ground Intelligence Officers attend Infantry Officer Course and the Scout Sniper Platoon Commanders Course to hone their infantry and surveillance skills. The SNCOs are all Infantry Unit Leader MOS 0369, being a Gunnery Sergeant (GySgt) for the Operations Chief and three SSgts for the SESs. Marines of this rank and stature bring a wealth of experience to the platoon, however they lack experience in ground reconnaissance and working in or with small sized elements isolated in non-permissive environments. With a focus on leadership development, the important system element for the officers and SNCOs is operator-training education [27]. Analysis of the leadership area of the DOTMLPF for key SE design requirements leads to design for quality and interoperability [27].

As per the GSP (*EF 21*) table of organization, the Platoon Leader rank will receive upgrading from 1stLt to Captain, which will allow a more experienced officer to be in charge of the platoon, supervising the employment of UGS and networking with other units that will receive SETs as enablers. A GSP is more complex than is an infantry platoon and has more unique technology than does a scout sniper platoon. In addition, the GSPs could have their SETs spread throughout the MEF AO, so the Platoon Leader will have to coordinate with several other units to ensure the proper welfare and employment of his Marines. All of these factors require a senior company grade officer for leadership. The addition of reconnaissance SSgts to the SETs allows the teams to be under the leadership of a SNCO, which ensures a more mature ground reconnaissance specialist leading a maneuver element ready for attachment to another unit for deployment.

The quality of leadership the GSPs currently have is just and balanced, however the increased demands of *EF 21*, require an officer and SET Leader rank increase to handle the new demands placed on the GSPs. The addition of a Platoon Chief billet for an Infantry Unit Leader GySgt and an Operations Chief billet change to a reconnaissance SSgt will greatly enhance the leadership of the GSP. These changes aid in allowing the

GySgt to be able to focus on the day-to-day platoon events and logistics while allowing the reconnaissance SSgt to focus on coordinating training and missions for the unit.

In order for the GSP leadership to be interoperable, its officer and SNCOs must be capable of understanding, planning, and briefing all facets of UGS operations at all levels of the MEF. Getting missions and supporting missions is an added benefit that this unit has because it does not always deploy as a platoon. For this reason, the SETs are the base maneuver element and must maintain the highest possible readiness levels so that once a mission is levied upon it the SET is able to accept it. This requires leadership with interoperable skills to relate to all levels of the chain of command and to communicate effectively throughout those levels. Having a Captain as the Platoon Leader, GySgt as the Platoon Chief, and SSgts as Team Leaders will greatly increase the interoperability of the GSPs. From networking, to briefing, planning, and tactical on-the-ground leadership, this rank increase will greatly aid the GSPs in completing *EF 21* intelligence collections missions.

G. PERSONNEL

Meeting the emerging demands of *EF 21* will require significant changes to UGS personnel management. Although the GSPs currently support MEU and other operations with great success, they have the potential to expand significantly given the right tools and skills. The GSPs currently possess a talented blend of the Ground Intelligence Officers, Infantry Unit Leaders, and Rifleman MOS fields with additional Field Radio Operator and Intelligence Specialist structure in some select areas, which is supportive of modern day operations. However, the quantities and ranks need adjusting to meet the demanding goals of *EF 21* intelligence collections. The GSPs structure and personnel will gain credibility from a merger with the reconnaissance MOS field. UGS, regardless of their respective form of intelligence, are ground surveillance assets, which requires surveillance specialists, which, as displayed in Chapter III with the training and readiness task analysis, is why the reconnaissance MOS exist. Additionally, the SPIE capability would serve as a force multiplier for the UGS community, where it too falls within the skill set of the reconnaissance community. The changing roles of UGS-related personnel

in the USMC required by *EF 21* demands focus on the key system element areas of operator and maintenance personnel [27]. The key SE design requirements for personnel changes related to the USMC's use of UGS to support *EF 21* would be best oriented in the area of design for supportability (serviceability) [27].

The operator personnel are currently adequate for today's needs to support MEU, MAGTF and other operations as tasked. To meet the expanded needs of *EF 21*, the GSP (*EF 21*) table of organization reflects additions of reconnaissance and intelligence Marines to advance the roles of the operator personnel in the GSPs. As previously discussed in this chapter, the reconnaissance Marines will bring highly valuable ground reconnaissance and SPIE capabilities to the GSPs, the Intelligence Specialists would bolster the unit's intelligence analysis and collections capability. The emerging current COIN, counter terrorism, security, and stability operations reflect the growth of a crafty, innovative, adaptive, complex enemy with varying force projection. To the GSPs, this means ground maneuver and intelligence collections assets need subject matter experts with respect to the enemy in addition to intelligence collections assets in support of UGS employment missions. The addition of the Intelligence Specialists to the platoon HQ Tm and SETs will foster a better understanding of the battlespace, better fusion of UGS with the overall intelligence collections plan, and more accurate pattern analysis of UGS activations.

The maintenance personnel are well structured and equipped to handle the needs of *EF 21* with the addition of the technicians to the GSPs as per the GSP (*EF 21*) table of organization. TRSS technicians at the SETs could allow for a second echelon maintenance capability at the lowest level possible, as well as the addition of a Marine to the team that is skilled in radio operations, radio maintenance, who can also receive training to become a TRSS monitoring specialist.

The GSPs must be capable of supporting the needs of *EF 21*, to do so the SETs need skill sets of the reconnaissance, infantry, intelligence, communications MOS fields as well as the TRSS Technicians, MOS 2848. The numbers and ranks are debatable, but to meet the demands of the Surveillance Sensor Operators for *EF 21* all these skill sets must be present, which means advanced training and secondary roles for all the team

members. Availability in the context of personnel for the GSPs means its billets must receive staffing from qualified individuals. Currently, the GSPs lose some HQ Tm members and SES level members either as trade space for other MOSs elsewhere in the intelligence battalion's or the billets do not get staffed due to shortages. The GSP table of organization may need work to fit the needs of *EF 21*, but regardless of the organizational issues, the qualified personnel must exist to be ready to support the needs of the MEFs and MAGTFs.

H. FACILITIES

The Intelligence Battalions currently possess great work sites and are on bases with multiple training sites, maintenance sites, equipment storage sites, vehicle storage sites, and armories. These sites will need modifications to meet the demands placed on the GSPs from *EF 21*, such as storage and maintenance areas for with new technologically advanced UGS with their components, as well as SPIE related equipment. SPIE related facilities consist of storage sites for combatant dive, parachute, small boat, and HRST specific equipment. Passionate Marines enjoy the challenge of finding unique and challenging training sites, and this challenge will remain as the role of GSP changes for *EF 21* with the additional requirement for modifications for longer range patrolling to employ the UGS and SPIE missions. System element areas of concern for GSP's facilities may require modifications for the operational real estate, which consists of the command post, equipment storage sites, vehicle storage sites, armories, and training sites [27]. The main SE design requirements of supportability (serviceability) need addressing to upgrade the UGS-related facilities for *EF 21* [27].

The sites must support the mission, storage, training, simulators, planning spaces, and work spaces. In theory this is not difficult, but in execution it requires time, resources, and funding for upgrades. Due to their high-risk nature and associated high quantities of equipment, current GSP facilities may be unfit to support SPIE operations. This and any other added capability would be tethered to facilities upgrades, which if done correctly and safely will require significant time and funding. The result is a working area that is functional, safe, serves the mission, and protects the equipment while

having access to needed training sites, off host station if needed, to prepare the GSPs for the employment of UGS at any time and in any place.

I. CONCLUSION

Utilizing the SE design process for UGS in the USMC to support *EF 21* creates a model for accurate solutions to support the true needs of the warfighter. Focusing on the sections of SE design elements and requirements for analysis and applying them to each area of the DOTMLPF lays a well-structured foundation to cover all facets of the issue. Updating the doctrine for commonality and relevance will create products with greater utility for those tasked to employ UGS. Using the GSP (*EF 21*) provides the new organizational structure needed to better support the USMC's needs with UGS through the employment of the GSP or its SETs to support the MAGTFs. The training requires upgrades to support the organizational changes and demands of *EF 21*, allowing for the testing and integration of the GSPs to support advance intelligence collections missions, example as displayed in Chapter I, Figure 3. TRSS needs revamping to become a system comparable to that of McQ or ADAPT, to provide the GSPs the level of flexibility and maintainability they deserve. Adding the reconnaissance MOS field to the GSPs while increasing the intelligence and technician roles creates the structural personnel balance the units need to conduct surveillance missions for *EF 21*. The facilities upgrades come tethered to the capabilities and technologies upgrades, requiring increased access to training areas, storage for UGS, SPIE, and field equipment, and a command post for planning. These changes will produce a sound GSP, skilled with the most advance UGS, capable of integrating with numerous intelligence collections assets to support any MAGTF for *EF 21* missions.

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V. CONCLUSION

A. SUMMARY

The research described by this thesis regarding the employment UGS in the USMC reviews the most accurate and current literature, unit and individual Military Occupational Specialties (MOS) information, and technological data to support a systems engineering analysis. Defining *EF 21* at the forefront served as the lens through which to view the research. Chapter I contained the information on relative DOD Joint doctrine, with topics from both intelligence and maneuver fields to set some of the overarching conditions for the thesis. Following this and the definition of *EF 21* are three critical vignettes for the use of ground reconnaissance forces and UGS (Figures 1–3, Table 1) to visually display key employment concepts. Based on the research conducted for this thesis, final recommendations include the synchronization of UGS related doctrine for the USMC, new UGS technology similar to that of McQ Incorporated, and a new Ground Sensor Platoon (GSP) table of organization bolstering the roles of the Sensor Employment Teams (SETs) and fusion with reconnaissance Marines for advance UGS employment capabilities. This chapter established boundaries and conditions for the remainder of the thesis.

The literature review and analysis from Chapter II covered the key issues for the history, doctrine, and new concepts associated with the employment of UGS. The history of UGS provides insight as to the origination and recent use of UGS for the USMC; from the jungle perimeter security and reconnaissance missions of Vietnam to the counter Improvised Explosive Device (IED) missions of OIF and OEF, UGS were able to shape and assist the USMC's intelligence collections capabilities. The *Remote Ground Sensors*, *MAGTF Intelligence Collections*, and *Ground Reconnaissance* publications provided the doctrinal background needed to establish analysis on present use of UGS in the USMC. The *EF 21 Capstone* and *MCISR-E Roadmap* provided significant concepts as to needed future use of UGS. Closing this chapter was a review of the thesis, *Mobile Situational Awareness Tool: Unattended Ground Sensor Based Remote Surveillance System*, which contains very useful data on how the Defense Advanced

Research Products Agency (DARPA) technology can support the USMC's needs for UGS employment. The literature reviewed provided sound justification for areas of modification and implementation to foster advancements in UGS employment to support *EF 21*.

Chapter III explores the research conducted on the USMC's reconnaissance battalions and intelligence battalions, training, and technology associated with UGS. Clear definition of the UGS related roles for the intelligence battalions and reconnaissance battalions support table of organization modifications for new *EF 21* intelligence collections requirements. A detailed breakdown of the Surveillance Sensor Operator and Reconnaissance Man MOS occurs in this chapter to account for training requirements, individual capabilities, and UGS related tasks for the present USMC. Comparison and analysis of these unit and MOS facts show common practices between them and differences that may support *EF 21* or demand changes to do so. Presentation of the technology associated with UGS design and capabilities detailed the existing government off the shelf system, TRSS; the commercial off the shelf system, the McQ Inc. UGS; as well as the DARPA Adaptive Sensor System (ADAPT) prototype system. With TRSS being the current USMC system, it shows reliability and an established relationship but has significant capabilities gaps when compared to the other two systems reviewed. McQ has several advanced UGS with significantly unique capabilities used by several DOD elements but is a commercial company and would require screening or processing through the lengthy DOD acquisitions programs. DARPA ADAPT presents a unique type of UGS that is specific yet flexible and dynamic in that it offers insight into a new employment direction with multiple networked nodes. However, this system alone would require augments for a long range imaging capability and other features only offered by McQ, let alone the completion of its development and establishment of a production capability. Comparisons of these equipment types, as displayed in Table 8, fosters an *EF 21*-based analysis that provides justification for the reorganization and shaping of UGS management and operations to gain and maintain the most relevant technological capabilities for rapid deployment by the USMC.

The SE analysis of UGS in the USMC for *EF 21* presents a sophisticated method to develop a solution to the need for advancements in this field. Using Blanchard's *Systems Engineering Management* for the analytical foundation and the Doctrine, Organizations, Training, Materials, Leadership, Personnel, and Facilities (DOTMLPF) grouping as a guide, implementation of Figure 34 as a new table of organization aids in satisfying the USMC's needs. This solution called for a restructuring of the GSP to delete the Sensor Employment Squad (SES) and reduce the SETs, while increasing the size of the SETs and diversifying the MOS structure in the platoon. The addition of SSgt reconnaissance Marines to the platoon creates a new leadership and training role to advance the field skills and Special Insert / Extract (SPIE) capability of the platoon, while enabling longer, higher risk, and more advanced missions. The increased roles of Intelligence Specialists and UGS Technicians allows for greater combat support to the SET level, as seen fit by the Platoon Leader. The modified rank and structure of the Headquarters Team (HQ Tm) allows for advanced leadership for employment and networking, as well as more robust and creative training to support *EF 21* missions for MAGTFs. Using McQ and DARPA ADAPT as technological models, recommended advancements to the UGS equipment for the USMC will greatly increase the potential of UGS to complete *EF 21* tasks. These solutions set the stage for a reshaping of USMC structure and equipment to increase readiness, flexibility, adaptability, maintainability, and utility.

B. ADDITIONAL RESEARCH AREAS

The first area of recommended future research is to conduct field-testing of the limits of the technological capabilities of the different UGS. This thesis research is on data collected for the prescribed published capabilities of each of the different sensors. Due to time limitations and availability of equipment, no actual field-testing took place to see which UGS worked best under certain conditions. To mitigate this, reviewing extensive field data from previous tests aided in the analytical efforts, however these data sets were not specific to this research. Benefits this research would bring to exhibit the capabilities of the equipment in a field performance evaluation, in addition to the factual research conducted by this thesis, would add additional accuracy to the final assessments.

UGS integration with Unmanned Aerial Systems (UAS) testing would provide extensive insight into a related area that is of high interest. UAS such as Predators, Shadows, and Scan Eagles have been essential elements of the USMC intelligence collections plans for the past ten years. Finding ways to integrate them, with UGS as the cueing asset, have been rare and challenging. Research into defining this integration to optimize the use of UAS would greatly benefit the DOD due to the high demand, workload, and stress of existing UAS. This thesis focused more analysis on the ground aspect, which has great utility in an area that may deny the U.S. military use of its air space. However, as UAS research and development continues to grow, with small quad rotors and man-portable UAS so grows the utility and flexibility of the assets. Research into the integration of UAS with UGS has great potential to advance MASINT and IMINT collections integrations methods and maximize the use of scarce assets.

An air delivery (AD) capability for UGS has been a unique and well sought after feature since the Vietnam War. It is a capability that has seen some success, however the UGS were always difficult to aim, required aircraft to fly missions of increased risk or abnormal flight patterns, and often required several UGS for one mission due to damages on insert. With modern technological advancements and the risk to personnel for emplacement of UGS, AD UGS are becoming more intriguing. The USMC experimented with very large AD UGS in 2006; however, the program never materialized. McQ and ADAPT both had an AD capability that could be tested, for this is a capability in which the USMC still has interest and for which it desires assets. An advanced, usable AD UGSs capability for the USMC would allow for employment opportunities that provided zero risk to Marines on the ground, which would be an amazing and highly desired outcome. Additionally, a similar research study could be conducted for the employment of UGS with artillery assets, related to the family of scatter-able mines for conventional munitions. Research in this field, combined with this thesis, would advance the USMC's UGS in a new direction with an added capability.

Field-testing for the employment of UGS with reconnaissance Marines and Surveillance Sensor Operators should establish a baseline for support to UGS employment for *EF 21* intelligence collections operations. As discussed in Chapter II, the

reconnaissance battalions have many more training events and Mission Essential Tasks (METs) than the GSPs, all focused on advanced tactical missions. However, the GSPs tasks are focused, direct, technical, and oriented on the employment of UGS. Given a scenario, testing the two fields on ground tactics, the reconnaissance Marines vs the GSP Marines, would generate great insight as to who is best to work with UGS under *EF 21* conditions. Forming a combination of the two fields, as shown in Figure 34, has great potential for the UGS community; however, testing for confirmation and research could validate this approach.

With the U.S. Army and the USMC possessing similar ground intelligence collections capabilities yet vastly different structures, analysis done to compare these factors would generate interesting research. With the U.S. Army revamping their UGS program, such research provides great potential for a fielding plan and maintenance structure, one that could be unique and different from that of the USMC with TRSS. In addition, the U.S. Army recently reorganized their reconnaissance and intelligence units to form Battlefield Surveillance Brigades (BFSBs) [28]. These BFSBs contain many different specialties, such as UGS, a ground reconnaissance squadron, and UGS platoon in a military intelligence battalion [28]. All of these assets rest under one brigade command oriented on focused ground intelligence collections to support answering the intelligence requirements of a division, corps, or Joint Task Force [28]. Research into this area would show if this structure could enhance the USMC's ability to provide ground reconnaissance and intelligence support, and possibly create better UGS employment methods.

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